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This report is the second of a series of annual reports to Congress presenting a five-year projection of environmental research activities to be conducted by the U.S. Environmental Protection Agency. The general role of environmental research is discussed in the context of the Agency's regulatory and assistance functions and the National goal of protecting and enhancing the environment.

Anticipated research over the next five years is discussed for each of the fourteen subprograms, as well as for six "current interest modules" which cut across several of the subprograms. The dominant programs in the forecast period are health effects studies and energy-related comprehensive environmental research. Impacts of level and increasing budgets on scheduling of program outputs are discussed.

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ENVIRONMENTAL RESEARCH OUTLOOK

FY 1977 through FY 1981

REPORT TO CONGRESS

OFFICE OF RESEARCH AND DEVELOPMENT
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

This report has been reviewed by the Office of Research and Development, U.S. Environmental Protection Agency, and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

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FOREWORD

Prudent environmental management must rest on a sound technical and scientific basis. The development of such a base depends on a strong, viable and timely research effort. I strongly believe that the Environmental Protection Agency's research must both anticipate future requirements as well as be responsive to the present needs of an Agency whose mandate is to protect and enhance the quality of the environment.

This document is the second in our series of annually-updated summaries of environmental research activities, priorities, and trends. Comments received from around the Nation on our first issue were extremely valuable in restructuring basic material for this version. As before, we have attempted to raise issues and identify where and when environmental problems will be occurring and when they might be solved.

The original five-year outlook provided a useful vehicle to establish a dialogue among concerned parties. Continuing the dialogue will allow building a meaningful and responsive program based on the outcome of the resolution of various issues raised. I hope that this dialogue will be maintained in the future.

As always, I invite your comments and suggestions on both the Research and Development Program and the "Outlook".

Wilson K Talley
Wilson K. Talley
Assistant Administrator
for Research and Development

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SECTION I

THE OUTLOOK

INTRODUCTION

The U.S. Environmental Protection Agency (EPA) was created by Presidential order in December of 1970. This order brought together fifteen programs from several Federal Government agencies to mount a coordinated attack on environmental problems. These problems include air and water pollution, solid waste management, pesticides, water supply, radiation, noise and toxic substances.

The mission assigned to the Agency is to protect and enhance the quality of the environment. As man's interactions with the environment become increasingly prevalent, it is sought to reduce the detrimental impacts of those actions to achieve the national objectives of improved health and welfare for our citizens.

In pursuit of its mission, EPA must achieve its objectives in a manner that is consistent with other national goals. Since environmental impacts are associated with nearly all human activities, EPA must act to assist, coordinate, and direct the fight against environmental degradation on a national basis. This requires coordination and cooperation with the numerous national, state and local institutions (private as well as public) and their respective environmental program activities and skills.

The Agency approaches this national objective through several different means:

- Informs the public on environmental matters.
- Conducts an environmental research program.
- Disseminates information on environmental problems, their sources, impacts and solutions.
- Assists state and local governments in a variety of planning and wastewater treatment construction activities.
- Demonstrates how to protect and enhance environmental quality.
- Provides technical assistance in the solution of environmental problems.
- Establishes environmental criteria and standards and assures the enforcement of environmental regulations.

The Office of Research and Development (ORD), in support of the Agency's mission, conducts a comprehensive and integrated research and development (R&D) program within the Agency to assure the development of:

- The scientific basis for environmental criteria.
- The technological basis to develop environmental control standards.
- Measurement methods and quality control for accurate and reliable quantification of environmental conditions for assessments, implementation and standards enforcement.
- Cost-effective pollution control technology alternatives and incentives for implementing environmentally desirable options.
- Scientific, technical, socioeconomic and institutional methodologies for judging and balancing environmental management options against competing national needs.

The ORD therefore functions to seek, identify, characterize, and understand environmental interactions, and to develop minimum impact alternatives to man's demands on the environment. The ORD's research is complemented and supplemented by general scientific and technical research of other national institutions (Federal agencies, universities, private industry and research organizations and elsewhere).

More general functions of ORD include the development and maintenance of government expertise capable of responding to emergencies and providing expert consultation and testimony when necessary; sharing the results of environmental R&D with a wide range of individuals, institutions, and agencies in ways that are meaningful and practical; and providing expert scientific and technical assistance to other EPA offices to aid in the formulation of environmental policy and regulations. The ORD also supports the Agency's activities in many international organizations with mutual environmental R&D concerns.

What follows is the second annual five-year Research Outlook. It describes in general ORD's projected research program options within certain constraints for the FY 1977 - FY 1981 period, including the rationale, resource needs and priorities. The purpose of the report is to present a flexible research plan to support the Agency's mission. This plan, as implemented, will result in coordinating the national requirements to understand the factors affecting the quality of our environment. It should also result in developing means to protect and enhance the environment. An updated report will be issued each year, reflecting changes, if any, in emphasis within programs and the anticipated nature of environmental research during the five-year period which follows the year of publication.

As a public document, the plan also becomes a vehicle to solicit the views, opinions, needs and criticisms of all public and private institutions concerned with the environment.

The plan is supplemented by a series of more detailed reports whic' highlight past year accomplishments; provide a program guide description to the current budget year, and describe the research focused on current interest environmental issues (module reports). A list of these to be issued during FY-1977 is as follows:

- ORD Program Guide - Fiscal Year 1977 (October 1976)
- ORD Environmental Research Outlook FY 1978-1982 (due February 1977)
- ORD Annual Report-Fiscal Year 1976 (due Spring 1977)
- ORD Current Interest Module Reports (due during FY 1977)
- ORD Subprogram Summaries (due during FY 1977)

LEGISLATIVE AUTHORITIES

The EPA is recognized by Congress as the official implementing Agency for a broad range of public laws addressing specific environmental problems. The principlal relevant legislation is listed in Table 1.

Over the past decade, the trend in legislation has been towards increasing Federal involvement in setting environmental quality regulations and, where appropriate, assuring that they are enforced. The necessity of having firm evidence on environmental damages in support of legal defense of ambient emission and effluent standards has had a noticeable effect on the internal priorities of EPA's research in recent years, i.e., increasing emphasis on human health and ecological effects in lieu of technology development. The latest environmental laws (toxics, solid and hazardous wastes) indicate a growing sophistication in the type of problems addressed (specific pollutants as opposed to general pollution indicators) and an increasing awareness of the interconnection of air, water and land pollution problems.

Each act of law contains general and specific mandates and authorities which require the acquisition or development of scientific and technical information. To meet these many different requirements efficiently, a research organization has evolved which groups disciplines and problem areas into manageable program areas.

ORGANIZATION

The organizational structure of the Office of Research and Development is based primarily on a time frame for research response to the various legislative demands, objectives and goals. A secondary consideration is size and nature of a generic research effort, while another is problem area. Organization by profession (discipline) or environmental medium (air, water, land) is not a major determinant in implementing the research program. This is because comprehensive analyses of problems utilizing the expertise of many different professions has been shown to be necessary in environmental research.

TABLE 1

SUMMARY OF LEGISLATIVE AUTHORITIES

PUBLIC LAW NO.	TITLE	YEAR PASSED
78-410	Public Health Service Act	1944
89-272	Solid Waste Disposal Act	1965
91-190	National Environmental Policy Act	1969
91-604	Clean Air Act Amendments	1970
92-500	Federal Water Pollution Control Act Amendments	1972
92-532	Marine Protection, Research and Sanctuaries Act	1972
92-574	Noise Control Act	1972
92-583	Federal Insecticide, Fungicide Rodenticide Act Amendments	1972
93-523	Safe Drinking Water Act	1974
- -		(New)
94-469	Toxic Substances Control Act	1976
94-580	Resource Conservation and Recovery Act	1976

Within ORD, major short-term response activities (primarily quality assurance, monitoring techniques and equipment development and technical support) responding to the immediate needs of other Agency programs, are grouped together under the Office of Monitoring and Technical Supports (OMTS).

The relatively more stable long-term activities, relating to the determination of the human health and ecological effects of pollutants are conducted by the Office of Health and Ecological Effects (OHEE).

The remaining research activities aimed at meeting legislative and Agency objectives through control or abatement technology--are, because of their nature and size, organized into two offices: the Office of Air, Land and Water Use (OALWU); and the Office of Energy, Minerals, and Industry (OEMI). These offices are primarily responsible for technological research and development, which includes pollutant source characterization, assessments of impacts (for example, of sources on ambient pollutant levels), and

and the development of abatement methods and technology. The OALWU addresses environmental problems primarily arising from public and agricultural sector activities while OEMI addresses those from activities normally associated with the private sector (i.e., industry). Where practical and justified, these offices administer and structure programs which are integrated with all other ORD programs, such as effects, transport, monitoring, etc.

These four offices plan and implement the research program which is divided into fourteen subprograms as shown in Table 2, and as described below.

TABLE 2

PROGRAM STRUCTURE VERSUS ORGANIZATIONAL STRUCTURE

Program Structure	Organizational Structure*			
	OHEE	OALWU	OEMI	OMTS
Health and Ecological Effects Program				
Health Effects	P I	I	-	I
Ecological Processes and Effects	P I	I	-	I
Transport and Fate of Pollutants	-	P I	-	-
Public Sector Activities Program				
Waste Management	I	P I	-	-
Water Supply	I	P I	-	I
Environmental Management	-	P I	-	-
Industrial Processes Program				
Renewable Resources	I	P I	-	-
Minerals, Processing, and Mfg.	-	I	P I	-
Energy/Environment Program				
Health and Ecological Effects	I	I	P	I
Extraction and Processing Technology		-	P I	-
Consv., Utilization, Tech. Assessments	-	I	P I	-
Monitoring and Technical Support Program				
Monitoring Techn. and Equip. Dev.	-	P I	-	P I
Quality Assurance	I	-	-	P I
Technical Support	-	-	-	P I

*Legend
OHEE: Office of Health and Ecological Effects
OALWU: Office of Air, Land, and Water Use
OEMI: Office of Energy, Minerals and Industry
OMTS: Office of Monitoring and Technical Support
P: Office has program planning responsibility.
I: Office has program implementation responsibility.

Health Effects is a research program where scientists evaluate human health hazards associated with pollution in a number of media and categories, including air, water, pesticides, non-ionizing radiation and toxic chemicals, in order to provide a scientific basis for setting ambient environmental standards to protect human health.

Ecological Process and Effects research determines the effects of pollutants on the structure and function of ecosystems and on components of such systems.

Transport and Fate of Pollutants research produces empirical and analytical methods to allow relating air, water and land pollution emissions to ambient exposures.

Waste Management research focuses on the prevention, control, treatment, and management of pollution resulting from community, residential or other non-industrial activities. This area includes collection, transport and treatment of municipal wastewater, control of land surface runoff and management of solid and hazardous wastes.

Water Supply activities include research necessary to provide a dependable and safe supply of drinking water, and to prevent health damage resulting from contaminants in drinking water.

Environmental Management research analyzes the institutional, economic, and decision-making problems faced by governmental multimedia environmental programs at the state, regional and local level, and evaluates new management methods for implementation of integrated environmental protection plans based on regional objectives.

Renewable Resources research activities encompass the development of total management and technological systems to control air, water, and land pollution resulting from the production and harvesting of food and fiber. This area includes the assessment of probable trends in the production of renewable resources and their resulting environmental impact.

Mineral Processing and Manufacturing research is concerned with point sources of all pollutants from the industrial sector of the economy. It is focused on those mining, manufacturing, service, and trade industries which are involved in the extraction, processing and production of non-energy materials into consumer products.

Energy Health and Ecological Effects research includes those efforts necessary to determine the environmental effects associated directly with energy extraction, transmission, conversion and use.

Energy Extraction and Processing Technology covers the characterization of pollutants sources, assessment of environmental problems and development of control methods to mitigate the environmental impact of the mining and processing of coal and other energy resources. Solid, liquid, and gaseous fuels, as well as such non-fossil energy sources as uranium and geothermal sites are considered.

Energy Conservation, Utilization and Technology Assessment research is aimed at assuring adequate energy production from fossil fuels with minimum damage to environmental quality. It includes integrated technology assessment, which identifies environmentally, economically, and socially acceptable alternatives for meeting national energy demands.

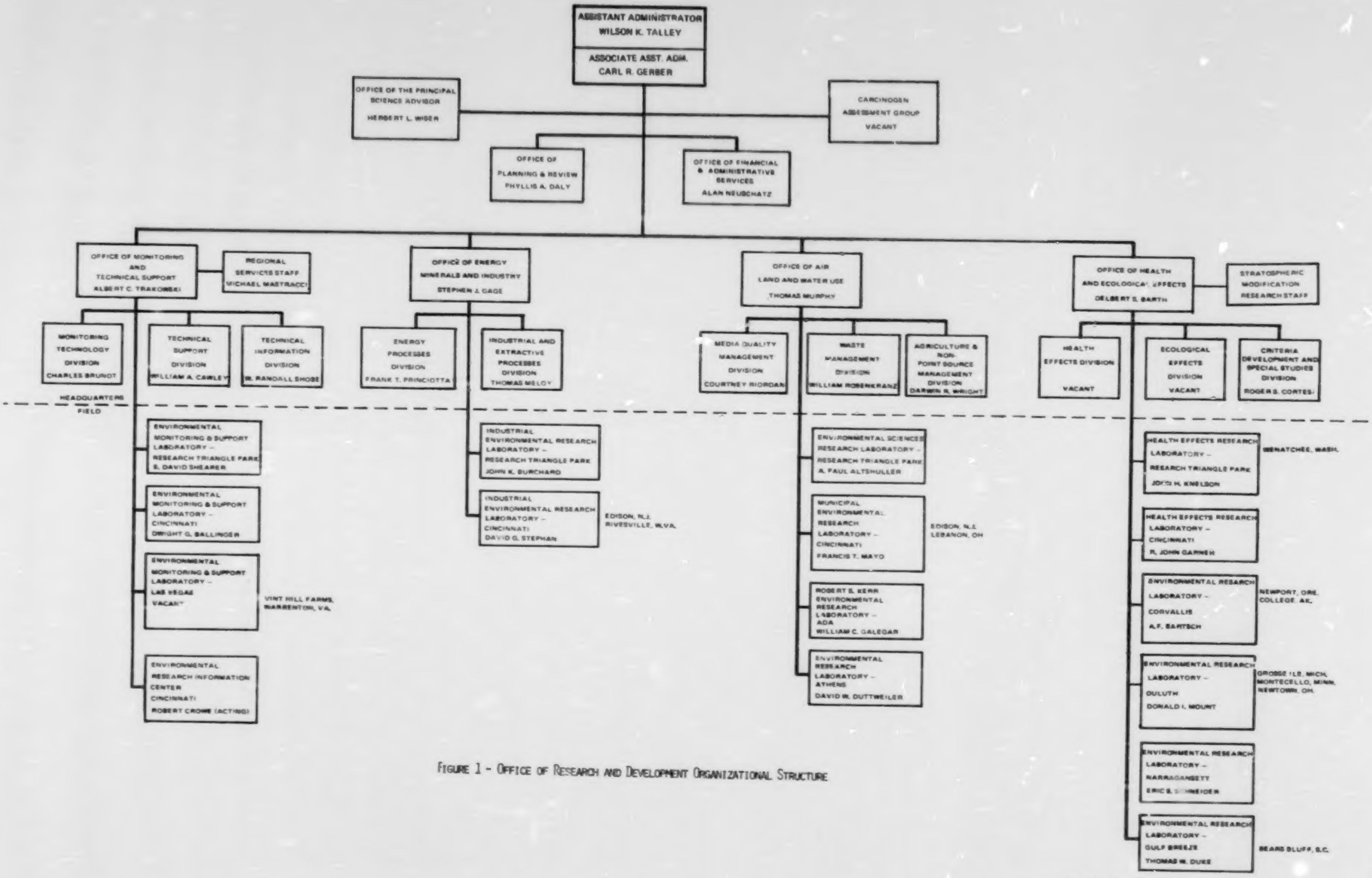
Monitoring Techniques and Equipment Development research develops methods, procedures and instruments to identify and measure pollutants based on physical chemical, radiological and biological principles.

Quality Assurance serves all environmental monitoring activities of the Agency. Its purpose is to standardize methods of measurement and to assure that monitoring data used to support regulatory programs are scientifically valid.

Technical Support is provided by the research program to other elements of the Agency. This is not research, but rather the application of recent findings in all fields, and the lending of research personnel and facilities to other parts of the Agency for immediate or unusual needs. This subprogram also includes ORD's research information dissemination activity, which serves the scientific information and data requirements of the Agency and state and local organizations by providing them with the latest information resulting from ORD programs.

Figure 1 presents the official structure of the Office of Research and Development, including the various laboratories. Table 2 shows how the fourteen subprograms are assigned among the five major program areas and four offices. Research planning activities are centered in a single office for all subprograms except monitoring and equipment techniques development (which is jointly conducted by OMTS and OALWU). This allows efficient utilization of personnel and program area skills. The implementation of the subprograms may occur in one or more ORD offices depending on the capabilities of the organizations and laboratories.

In addition to the program and subprogram activities described above, other activities are conducted by the ORD offices. Direct technical assistance to EPA operating programs is a continuous task of each ORD program. In to support of their assigned programs, activities such as socioeconomics and pollutant source characterization research are conducted as needed to directly support the objectives of each of the five major programs. All the major activities and their relationships with the four offices is shown in Figure 2. Here it should be noted that there are integrated activities among the four offices, with scientific research flowing into technology research to assist in formulating technological objectives. The final products delivered to the operational programs are shown as the "base" and outer envelope of Figure 2, since Technical Support/Assistance and Quality Assurance subprograms are designed to be responsive to the near-term needs of the Agency.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ENVIRONMENTAL RESEARCH LABORATORY – GULF BREEZE THOMAS W. DUKE
BEARS BLUFF, S.C.

FIGURE 1 - OFFICE OF RESEARCH AND DEVELOPMENT ORGANIZATIONAL STRUCTURE

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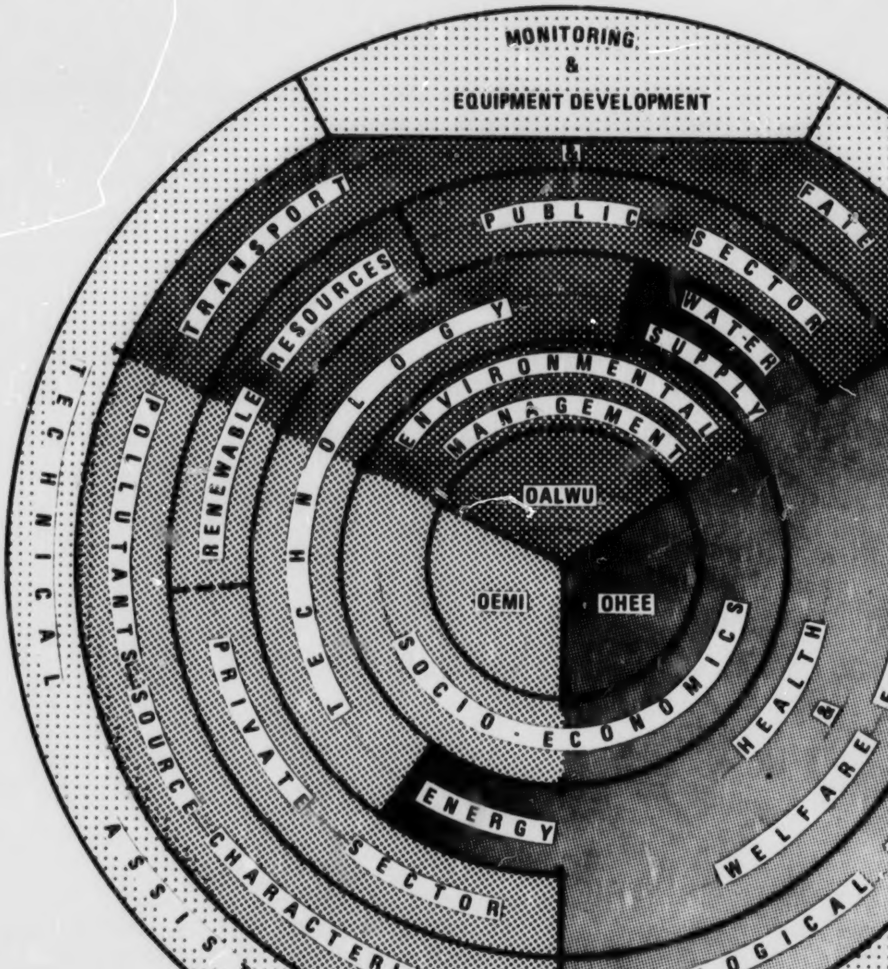
MONITORING
&
EQUIPMENT DEVELOPMENT
TRANSPORT
PUBLIC SECTOR
FATE
RESOURCES
WATER
SUPPLY
TECHNOLOGY
ENVIRONMENTAL
MANAGEMENT
OALWU
RENEWABLE
OEMI
OHEE
POLLUTANTS SOURCE CHARACTERIZATION
PRIVATE SECTOR
ENERGY
SOCIO-ECONOMICS
HEALTH & WELFARE EFFECTS
ECOLOGICAL PROCESSES & EFFECTS
TECHNICAL ASSISTANCE & SUPPORT
OMTS
QUALITY
ASSURANCE

FIGURE 2 - INTERRELATIONSHIPS BETWEEN ORD ACTIVITIES AND OFFICES

LABORATORY FUNCTIONS

The principal functions of the headquarters ORD staff are planning, coordination and review of the Agency research program. Functionally, this is accomplished through continuous comparison of research needs with program outputs, leading to preparation of annual "Objective Statements," which are transmitted to one or more of the fifteen laboratories for implementation. The Objective Statements address final research product specifications only. The laboratory to which a specific objective is assigned prepares an official "Accomplishment Plan" which outlines the specific methods for implementation of the research. Periodic headquarters/laboratory program review meetings keep EPA headquarters staff informed on the status of accomplishment of the stated objectives.

Each laboratory is headed by a Director who reports directly to one of the four Deputy Assistant Administrators in charge of the four principal headquarters offices. The fifteen laboratories all have distinct functions, and are accountable to their Deputy Assistant Administrator as described in Table 3.

TABLE 3

EPA RESEARCH AND DEVELOPMENT LABORATORIES

LABORATORY	FUNCTIONS
OMTS Laboratories	
Environmental Monitoring and Support Laboratory-Research Triangle Park, NC	- Air pollution quality assurance - Development of air monitoring methods and equipment - Fuels and additives registration - Technical support
Environmental Monitoring and Support Laboratory-Cincinnati, OH	- Water quality assurance - Development of drinking and waste water monitoring methods and equipment - Technical support

(Continued)

TABLE 3 (Continued)

EPA RESEARCH AND DEVELOPMENT LABORATORIES

LABORATORY	FUNCTIONS
Environmental Monitoring and Support Laboratory-Las Vegas, NV	- Development of remote sensing techniques for all media - Multimedia quality assurance - EPA coordinator for nuclear tests - Technical support - Operating of Agency airborne monitoring fleet - Biological monitoring
Environmental Research Information Center-Cincinnati, OH	- Technology transfer - Research Information dissemination
OEMI Laboratories	
Industrial Environmental Research Laboratory - Cincinnati, OH	- Technology development and environment assessments of food, fiber, non-ferrous metal, inorganic chemical, and miscellaneous industries, and energy conservation technologies
Industrial Environmental Research Laboratory-Research Triangle Park, NC	- Technology development and environment assessment for power utility ferrous metals, petroleum refining petrochemical, agricultural chemical, emerging energy industries and textile industries

(Continued)

TABLE 3 (Continued)

EPA RESEARCH AND DEVELOPMENT LABORATORIES

LABORATORY	FUNCTIONS
OALWU Laboratories	
Environmental Sciences Laboratory - Research Triangle Park, NC	- Characterization of air pollution emissions and their relationship to ambient air quality - Development of methods and instruments for indentification and measurement of air pollutants - Evaluation of air pollution effects on climate and atmosphere.
Municipal Environmental Research Laboratory - Cincinnati, OH	- Technology development and assessments for public sector wastes (municipal wastewater, urban runoff and hazardous and solid wastes) - Technology development to maintain and improve the quality of public drinking water supplies - Development of comprehensive environmental management methods
Robert S. Kerr Environmental Research Laboratory - Ada, OK	- Research on transport and fate of pollutants in ground water - Technology development and assessment of municipal waste waters by soil treatment systems - Research on control of pollution from irrigated agriculuture - Research on control of pollution from animal production
Environmental Research Laboratory - Athens, GA	- Research on fate and transport of pollutants in fresh water and soils

(Continued)

TABLE 3 (Continued)

EPA RESEARCH AND DEVELOPMENT LABORATORIES

LABORATORY	FUNCTIONS
	- Research on control of pollutants from nonirrigated agriculture and forestry - Develop methods for identifying and measuring pollutants in water, soil and sediment
OHEE Laboratories	
Health Effects Research Laboratory-Research Triangle Park, NC	- Impacts of air pollutants on human populations - Non-ionizing radiation effects - Clinical studies on impact of air pollutants on humans - Animal toxicological research to assess human hazards from multiroute exposure
Health Effects Research Laboratory - Cincinnati, OH	- Scientific health bases for setting ambient water quality standards - Scientific bases for setting drinking water standards - Animal toxicological studies of air pollutants from mobile sources - Water toxicological analyses
Environmental Research Laboratory - Corvallis, OR	- Effects of pollutants on terrestrial, fresh water and marine ecosystems - Biospherical modeling of pollutant impacts on ecological systems

TABLE 3 (Continued)

EPA RESEARCH AND DEVELOPMENT LABORATORIES

LABORATORY	FUNCTIONS
Environmental Research Laboratory - Duluth, MN	- Development of ecological effects criteria for pollutants in fresh water - Development of models of pollution in the Great Lakes
Environmental Research Laboratory - Narragansett, RI	- Development of ecological effects criteria for pollutants in marine waters
Environmental Research Laboratory - Gulf Breeze, FL	- Analysis of impacts of pesticides on marine ecosystems

THE ROLE OF RESEARCH

With the thrust of recent legislation, the process of environmental protection has become principally regulatory in nature. The role of research in this process is to improve the effectiveness of protecting and enhancing the environment. This requires providing new information and developments which allow early detection and resolution of new environmental problems and continued improvement in the resolution of recognized problems. This role of research is shown in Figure 3, where research in monitoring, transport and fate, health and ecological effects and impacts, technology development and environmental management are shown as interdependent functions providing new and improved inputs to the program offices which will increase the capability for applying the most appropriate restrictions on environmental pollutants through regulations.

The regulatory process can, in theory, be conducted in the absence of new research findings, using as a basis for the regulations current "state-of-art" information. This approach is not amenable to control pollution from new problem areas, nor may it be adequate to effectively resolve currently known problems. In recognition of this, Congress in the passage of environmental legislation, has specifically required and authorized that R&D be conducted in the majority of cases.

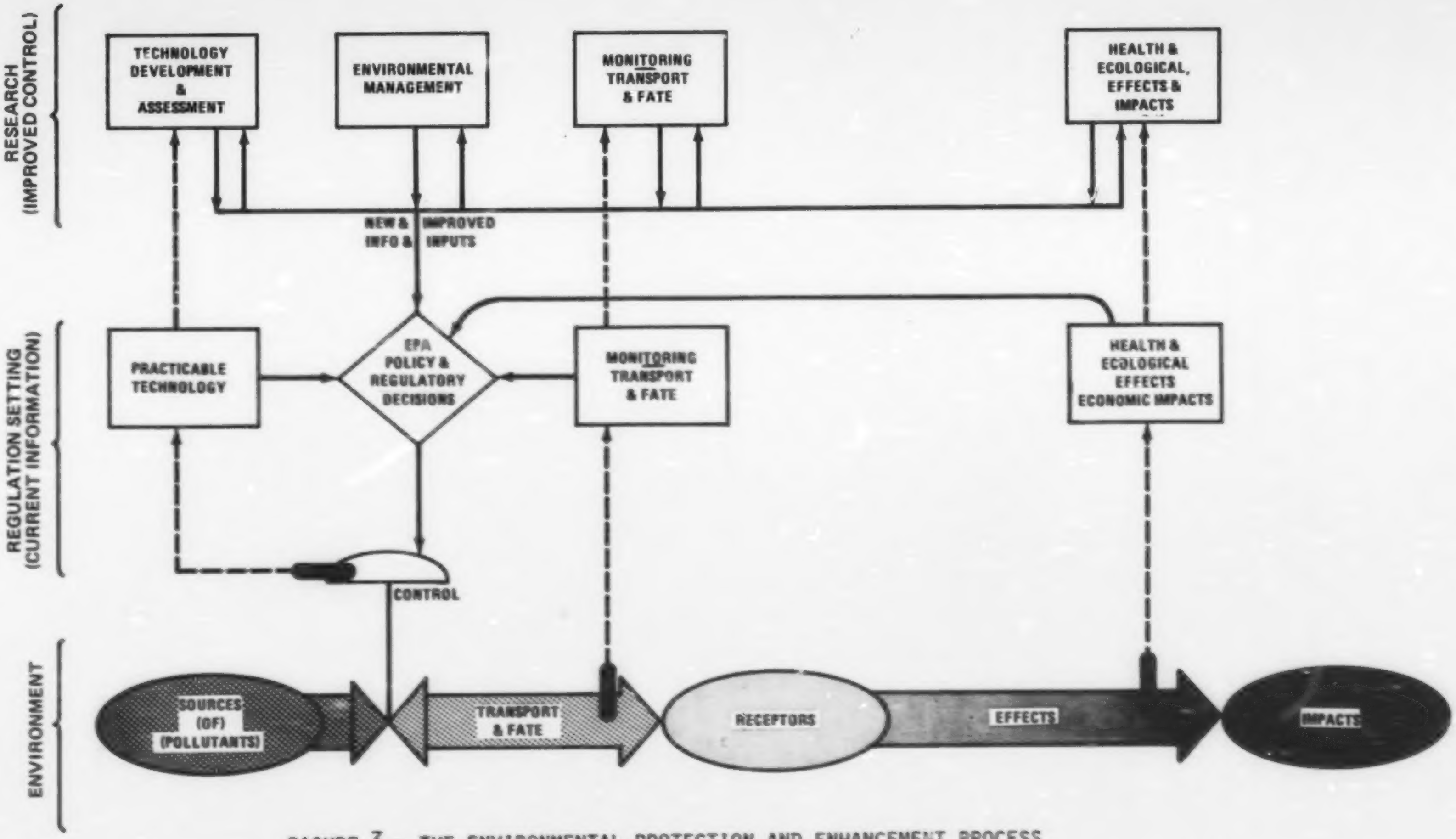
RESEARCH (IMPROVED CONTROL)
REGULATION SETTING (CURRENT INFORMATION)
ENVIRONMENT
TECHNOLOGY DEVELOPMENT & ASSESSMENT
ENVIRONMENTAL MANAGEMENT
MONITORING TRANSPORT & FATE
HEALTH & ECOLOGICAL, EFFECTS & IMPACTS
NEW & INFO & IMPROVED INPUTS
PRACTICABLE TECHNOLOGY
EPA POLICY & REGULATORY DECISIONS
MONITORING TRANSPORT & FATE
HEALTH & ECOLOGICAL EFFECTS ECONOMIC IMPACTS
CONTROL
SOURCES (OF) (POLLUTANTS)
TRANSPORT & FATE
RECEPTORS
EFFECTS
IMPACTS

FIGURE 3 - THE ENVIRONMENTAL PROTECTION AND ENHANCEMENT PROCESS

With no research, a stagnant regulatory condition could prevail, one where existing problems may only be partially corrected, and where the capability to deal with new problems would be very limited. This is because the private sector has few incentives to develop new environmental information and control technology. Therefore, if the mission of EPA is to protect and enhance the environment from current impacts and from growing pollution potentials, research is not a separable function of the Agency, but an integral one.

The ORD outputs, as a part of the regulatory process, provide a measure of objectivity to the Agency's regulatory decisions. This results because ORD, as an independent entity within the Agency, is responsible directly to the Administrator for the information it develops and not for the development of regulations. The amenability of scientific research findings to analysis also adds an element of objectivity to program reported research. The practice of promoting a program's perception of research information is thus limited. To assure improved objectivity, ORD programs are becoming increasingly structured to involve the participation of multi-interest groups to evaluate ORD sponsored research information.

CONSTRAINTS

Legislative

In developing the research program, certain authorizations and constraints must be recognized. Key among these are the legislated authorizations and mandates. The major pieces of legislation under which EPA operates contain broad, essentially all-encompassing authorizations for research and development on the "effects, prevention, abatement, control" of pollution as shown in Table 4. Overlapping these broad authorizations are many specific authorizations or even mandates that relate to work on specific problems (e.g., acid mine drainage, lake restoration, automotive emission controls, etc.), or that authorize certain special types of funding mechanisms for eligible grantee or contractor organizations. In addition there are other implied mandates for R&D that derive from implementation dates for major environmental protection regulations and legislative objectives and goals.

In addition to the direction of authorizing Acts, other Congressional mandates are often found in Appropriations Reports. In FY 1976, for example, the Congressional Appropriations and Conference Reports contained specific guidance for R&D on assessment of the potential environmental, social, and economic impacts of the proposed concentration of power plants in the lower Ohio River Basin and an assessment of environmental factors having an adverse impact on the Chesapeake Bay, including establishment of data collection and monitoring systems, determination of governmental units that have management responsibility and how such responsibility can be structured so that communication and coordination can be improved among all concerned parties.

TABLE 4. LEGISLATIVE BASE FOR ORD RESEARCH

	Legislative Base											
Research Programs and Subprograms	Public Health Service Act	Solid Waste Disposal Act	National Environmental Policy Act	Clean Air Act Amendments	Federal Water Pollution Control Act Amend.	Marine Protection, Research and Sanctuaries Act	Noise Control Act	Federal Insecticide, Fung. and Rod. Act Amend.	Safe Drinking Water Act	Toxic Substances Control Act	Resource Conservation and Recovery Act	Interdisciplinary (with more than one authority)
Health and Ecological Effects												
Health Effects	●			●	●			●	●	●		
Ecological Processes and Effects			●	●	●	●		●		●		
Transport and Fate				●	●			●		●		
Public Sector Activities												
Waste Management		●			●	●			●		●	
Water Supply									●			
Environmental Management												●
Industrial Processes												
Renewable Resources		●		●	●							●
Minerals, Processing and Manufacturing		●		●	●					●	●	
Energy												
Extraction and Processing Technology				●	●					●	●	
Conservation, Utilization and Technology Assessment			●	●	●					●	●	
Health and Ecological Effects				●	●					●		
Monitoring and Technical Support												
Monitoring, Techniques & Equipment Development	●	●		●	●	●	●		●	●	●	●
Quality Assurance												●
Technical Support				●	●							●

Commitments

In formulating its research program, ORD must also remain aware of special commitments made for interagency cooperation and intra-agency support. For example, EPA currently provides ERDA an off-site nuclear test monitoring service. These commitments and how ORD interfaces with other Federal agencies are summarized and discussed in Section IV.

Resources

The economic climate in recent years has necessitated restrained governmental spending. It is presumed that this need for fiscal restraint may continue throughout the period covered by this program plan. Accordingly, this plan provides alternative implementation schedules to show how the plan would be executed under different resource constraints. The level option provides for the highest priority research and development required to meet the Nation's current environmental research and development needs.

The second option provides an example of tradeoffs which could be made under a similar budget constraint, but with changing priorities.

The third, or growth option, will permit responding to new legislative demands and current high priorities, as well as intiation and maintenance of an adequate level of long-term anticipatory research. This is an optimum option formulated not to meet all identified R&D needs but rather to meet only those which may be absorbed effectively by existing EPA programs at a manageable growth rate. This option is highly sensitive to personnel ceiling authorizations within EPA and ORD throughout the five-year period.

The program will continue to draw to the maximum extent possible on research being funded and conducted by other government agencies, industry and foreign countries.

In support of the policy to reduce Federal personnel levels wherever possible, EPA has been steadily increasing the ratio of extramural research (contract and grant) to intramural research (performed by EPA employees) over the past several years. This has been accomplished by gradually reducing the total number of research personnel from over 2000 in 1973 to less than 1800 in 1978, in the face of level or increasing responsibility and funding.

Through careful management, the proposed level budget program can be sustained over the five-year period within the FY 78 personnel ceiling. However, if program expansion as described in the growth budget and the subprogram growth areas described in Section II is desired, it must be accompanied by a significant relaxation of the personnel ceiling as shown in Table 5.

ORD conducts a continuing re-examination of the mode of conducting its operations. While this analysis has resulted in a shift of personnel from administrative duties to research management functions, there still remains skill shortages in selected areas. It is therefore planned to alter the technical skill mix over a period of years with a small influx of new positions targeted to fill specific skill shortages where present personnel skills cannot be redirected. In addition, adjustments will be accomplished by filling vacancies as they occur with the specific skills that are needed.

TABLE 5

ORD GROWTH BUDGET POSITION REQUIREMENTS FY 1977 - 81

	FY 1977	FY 1978	FY 1979	FY 1980	FY 1981
Base Positions	1709	1575	1763	1803	1843
Reimbursable & Others*	177	177	177	177	177
TOTAL	1886	1752	1940	1980	2020

*Consists of 40 Regional Representative, 88 ERDA, 14 Scientific Advisory Board, and 35 Substitute Chemical Program positions which are not under direct ORD control.

RESEARCH APPROACHES

The EPA's overall research program supports the mission of a regulatory agency. Specific research objectives and priorities primarily derive from needs established by the Agency in fulfilling its legislative mandate. Accordingly, the research program is highly "mission oriented" with emphasis on production of timely and quality outputs, i.e., research results that are directly useful to the Agency, the Congress, environmental decision-makers, regulatory officials, the public and private sectors.

While EPA is responsible for developing and coordinating a comprehensive Federal research program for environmental protection, actual research is carried out by many others. These include, but are not limited to, EPA laboratories, other government agencies (either through funded interagency agreements or through coordination with individual programs), and the user community, including state and local governments, industry, and universities.

In some specific areas of research, ORD does not play a lead role in the planning or implementation of research within the Agency. Rather the function is assigned to another office within EPA. In the case of noise pollution R&D, this activity is administered by the Office of Noise Abatement and Control, which, through contracts and interagency agreements, fulfills the research requirements of the Noise Control Act of 1972.

An example of its coordination role is ORD's energy-related environmental program. The EPA was directed by the Congress to coordinate an energy and environmental research, development, and demonstration program to ensure that environmental factors were considered along with the nation's activities to increase the production of energy. To meet this goal, ORD accepted the responsibility for integrating the efforts of sixteen Federal agencies in a coordinated Federal energy-environment program. The ORD's Office of Energy, Minerals, and Industry administers "pass-through" monies to other Federal programs to minimize duplication of effort and ensure efficient use of resources.

In view of the role of ORD, the R&D programs are largely applied research as opposed to basic research. To meet increased demands on the Agency within recent years, ORD has relied heavily on extramural grantees and contractors to conduct research. Except for those special problems where intramural capabilities are unique or necessary for immediate support of the regulatory function of the Agency, the internal EPA research effort will be maintained at a modest level.

The comprehensive nature and interrelationship of environmental pollution necessitates an intermedia (air, water, and land) approach to research. Since ORD attempts to develop solutions to total environmental problems, ORD programs must also be interdisciplinary (interaction among professional disciplines). As a result, the anticipatory research direction emphasized in this five-year plan is viewed through separate and new environmental interest modules. The relationship of these current interest modules to program areas is shown in Table 6. Here the interrelationship and interdependence of the ORD programs with one another become evident. These modules are discussed in detail in Section III. Their use and emphasis represents an additional program planning perspective based on current public interest in specific environmental perspective based on current public interest in specific environmental topics and concerns. The purpose of this alternative mode in highlighting portions of the R&D program across the organizational structure of programs is to provide for increased understanding by members of the public who may have a specific interest in these selected areas of ORD activities, and for highlighting areas desirable for future emphasis.

PRIORITIES

The setting of research priorities for a large and diverse subject such as the environment does not at this time lend itself to quantification using currently available analytical methods. Rather, it is a judgmental process which aggregates the judgments and opinions of various institutions with those of ORD and the Agency. Major considerations in establishing priority are as follows:

- Nation-wide applicability of research.
- Current state-of-the-art.
- Impact on environmental pollution control, or protection.
- Legislative mandates.
- Regional needs.
- Regulation setting needs.
- Public awareness and concern of problem area.
- Toxicity aspects, both short and long-term implications, on human health, on human welfare, and on ecological systems.
- R&D costs to arrive at meaningful conclusions.
- Beneficial economic impacts or implications.
- Amenability of problem to solution.
- Global effects and international aspects.
- Nature of work (operational vs research).
- Qualification of investigators (intra or extramurally).
- Availability of resources (budget constraints).

TABLE 6. ORD PROGRAMS AND CURRENT INTEREST MODULES

	Current Interest					
Research Programs and Subprograms	Nonpoint Sources	Carcinogens	Sulfates	Ultraviolet Radiation	Toxic Substances	Resource Conservation
Health and Ecological Effects						
Health Effects		A	A	(A)	A	
Ecological Processes and Effects	A		A	(A)	F	
Transport and Fate	A		A		A	
Public Sector Activities						
Waste Management	A				A	A
Water Supply		A			A	
Environmental Management	A			F	F	F
Industrial Processes						
Renewable Resources	A					
Minerals, Processing and Manufacturing			F	F	F	F
Energy						
Extraction and Processing Technology	A				F	A
Conservation, Utilization and Technology Assessments			F			A
Health and Ecological Effects					F	
Monitoring and Technical Support						
Monitoring, Techniques & Equipment Development	A	A	A		A	
Quality Assurance					F	
Technical Support					F	

Notes:
A - designates immediately planned action.
(A) - designates immediately planned action by other Federal agencies.
F - designates potential future research action.

The following guidelines were used to develop priorities for a balanced, comprehensive five-year research program to support EPA's mission:

- Major Emphasis for research designed to protect human health and welfare, including the integrity of natural ecosystems.
- A continuing effort must be maintained in being responsive to the immediate technical needs of EPA.
- An adquate program of quality assurance for EPA's pollution monitoring and measurement activities must be assured in order for the Agency to standardize its pollution assessment activities and to verify compliance to regulations.
- Comprehensive environmental/socioeconomic assessments should be integrated directly into base research programs where possible.
- Capability to address unforeseen problems must be increased so as to avert environmental degradation surprise.
- Technology development, assessment and demonstration efforts must continue to address selected high priority problem areas of the Agency.
- Solutions to environmental problems that minimize costs, energy usage and undesirable transfer of pollutants to other media should be emphasized.
- The ability to detect, identify and quantify pollutants must be maintained by a continuous analytical measurement methods effort.

TRENDS AND OPTIONS

Current trends in environmental activities have been toward greater quantification of the nature and effects of pollutants and the costs and benefits of control. Such gross conventional pollution parameters as suspended solids or biochemical oxygen demand are significant indicators of pollution. However, specific toxic or hazardous substances in emissions and effluents are now emerging as equally important. This trend requires greater research sophistication and effort to quantify effects, transport and fate mechanisms, and ultimate impacts.

Another trend is the realization of the need to address environmental problems and issues in a more comprehensive manner which more closely resembles actual conditions and reflects the tendencies of pollutants to migrate or impact large geographical areas. Advanced monitoring methods are becoming more important in providing broader surveillance of impacts. Environmental problems are rarely bound by jurisdictional boundaries, but rather, have regional, national, or even international implications. The regional approach to environmental remedies provides that dimension of comprehensiveness which appears necessary for meeting future environmental needs. This thrust has been recognized in all environmental legislation since 1970, including the toxic materials and resource recovery acts of 1976.

New problems arising must also be faced and incorporated into the research effort. For example, the concern of stratospheric modification by fluorocarbons catalyzing the depletion of the ozone layer has recently emerged. At the urging of the Federal Council on Science and Technology, EPA has assumed the role of lead Agency in funding and managing an interagency effort on the biological and climatic effects of stratospheric ozone reduction. This two-year research effort has been accommodated within the current program.

Current allocations of resources among ORD programs may be presented in various ways. To help in further understanding ORD research, resource allocations are presented by discipline (nature of work) and by category of emphasis. These are presented in Figures 4a and 4b, and are respectively based on FY-1978 and 1977 information. Figure 4a illustrates that 44% of the ORD budget is allocated to wholly scientific research functions as compared to 41% for technology research functions. When viewed by category of emphasis, Figure 4b illustrates that 40% of the ORD budget is allocated to energy environmental research, 12.1% allocated to interdisciplinary (in the sense of multi-category) research, 17.0% and 18.0% respectively for air and water quality, 6.0% for water supply, and 6.9% for the sum of solid waste, pesticides, toxics, and radiation.

Future Trends

In addition to the changing emphasis, direction, and interest of the environmental movement, the size and emphasis of EPA s research and development program in the future will be determined by many different factors. Some of these factors are cited below:

- Economic health of the nation.
- Need for environmental research relative to other social needs as perceived by the Congress and the Executive Branch.
- Administration policy relative to nature of research, i.e., basic, applied, technology, science, etc.
- Relative priority of environmental R&D needs as perceived by the Agency and by the Office of Research and Development.
- The amount of specific-problem environmental research conducted elsewhere in the Federal government, e.g., NSF, NASA, HEW, DOT, ERDA, HUD, USDA, etc.
- The rate of discovery of new problems versus the rate of solution of defined problems.

Since these and other relevant factors cannot be reliably predicted over the next five years, various level of effort options have been considered for environmental research programs under different funding schedules.

Assuming an optimum resource base it is possible to project to FY-1981 the relative resource allocations within ORD. These are shown in Figures 4c and 4d by disciplines and category of emphasis, respectively. The most significant change anticipated would be a relative increase in the control technology discipline.

By categories, the anticipated changes would be a relative decrease in energy-environment and an increase for both the solid waste and toxic categories. The latter reflects proposed responses to the Resource Conservation and Recovery Act (RCRA) and the Toxic Substances Control Act (TSCA) of 1976.

Level Budget

The Level Budget Option, Table 7a, shows how resources would be allocated if total resources and relative priorities remain at their current level. The new Resources Conservation and Recovery Act will be addressed. Toxic substances research could not be expanded beyond that level initiated prior to the passage of the Toxic Substances Control Act of 1976 (TSCA).

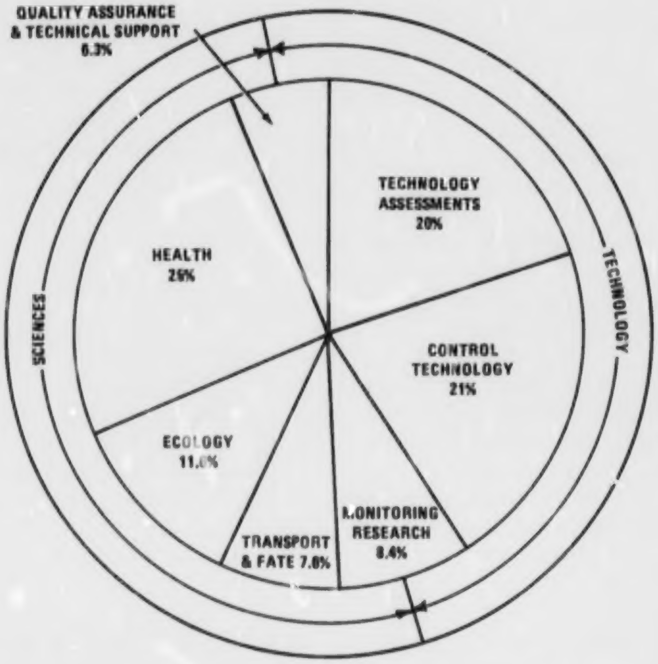

FIGURE 4a. RELATIVE ORD RESOURCE ALLOCATION BY DISCIPLINES

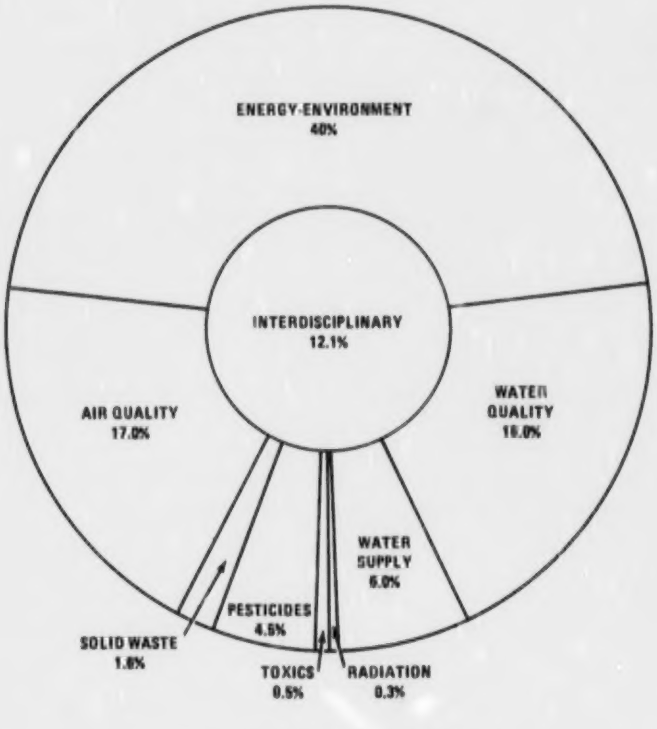

FIGURE 4b. RELATIVE R&D RESOURCE ALLOCATIONS BY CATEGORY OF EMPHASIS

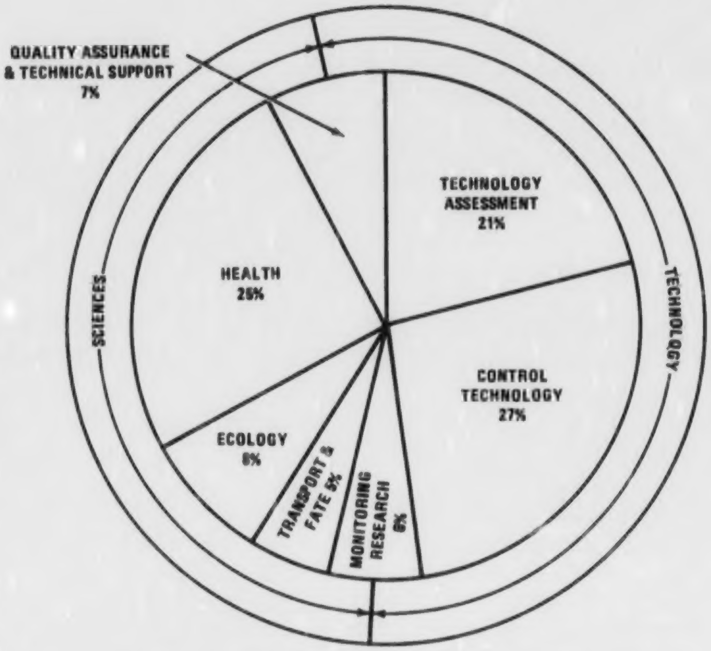

FIGURE 4c. PROJECTED 1981 RELATIVE ORD RESOURCE ALLOCATIONS BY DISCIPLINES.

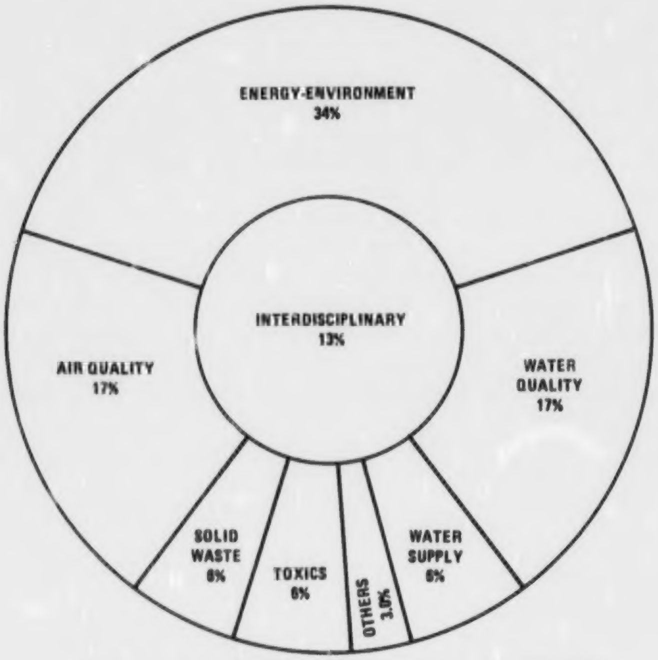

FIGURE 4d. PROJECTED 1981 RELATIVE R&D RESOURCE ALLOCATIONS BY CATEGORY OF EMPHASIS

Many low priority activities which address long-term needs and legislative goals would be phased out. In this option, most subprograms retain their FY 1978 share of the total ORD budget, and some, particularly ecological effects, energy, technology, and technical support are reduced to absorb the new demands. This budget would necessitate greater participation by other Federal agencies in environmental research related to the EPA programs objectives. To what extent this can be done under current EPA authorization is still uncertain (see discussions in Section IV).

Under these constraints, the careful setting of research priorities would be extremely critical, because lower priority projects might be delayed.

Modified Level Budget

This option, Table 7b, represents the same overall constraints on research and development funding, but shows how allocations would be adjusted in FY 1979-81 if it were determined that toxic substances research should be expanded irrespective of overall environmental research budget limittations. Response to TSCA would be increased by 7 million dollars in FY 1979, and maintained at that level through FY 1981. This increase would come at the expense of proposed new efforts in the energy, industrial, ecological, transport, water supply and pesticides areas. This budget option would allow toxics work to progress at about one-third the level described in Section III of this report, while the reduced areas could proceed only at the base level described in Section II, or, in some cases at a lower rate.

Growth Budget

The Growth Budget (Table 7c) provides for the maintenance of current activities, with provisions for additional budget increments to address the critical specific needs of new legislative mandates. It recognizes and provides for monetary inflation and general increases in depth of research required for solving new environmental problems. This option would allow increases in nonpoint-source, carcinogens, and sulfates module work as described in Section III, and quality assurance assistance to the Agency as described in Section II. Finally, most of the growth areas suggested in the subprogram descriptions in Section II could be accommodated.

TABLE 7a

LEVEL BUDGET OPTION
(by Fiscal Years in Millions of Dollars)

Subprogram	1977	1978	1979	1980	1981
Health Effects[a]	31.3	30.7	30.7	30	30
Ecolo. Proc. & Effects	19.0	16.8	16.8	17	17
Transp. & Fate of Poll.	12.7	12.7	12.7	13	13
Waste Management	14.5	18.5	18.5	19	19
Water Supply	13.2	15.2	15.2	15	15
Environmental Mgmt.	1.6	1.6	1.6	2	2
Renewable Resources Ind.	6.1	5.6	5.6	6	6
Minerals, Proc. & Mfg. Ind.	12.4	12.4	12.4	12	12
Energy Ext. & Proc. Tech.	25.4	24.4	24.4	24	24
Energy Cons., Util., Tech. Assess.	32.7	30.6	30.6	31	31
Energy Health & Eco. Eff.	35.2	39.2	39	39	39
Monitoring Tech. & Eq. Dev.	10.8	10.5	10.5	11	11
Quality Assurance	5.4	5.4	5.4	5	5
Tech. Support[b]	12.7	11.5	11.5	11	11
Toxic Substances Research[c]	1.4	1.4	1.4	2	2
Total[d]	234.4	236.5	236.5	237	237

[a] Excluding toxic substances research, which is highlighted separately for this presentation.

[b] Includes Energy Technical Support.

[c] Toxic substances research in progress prior to P.L. 94-469.

[d] Does not include program management, miscellaneous overhead, and special transfers which totaled $24.9 million in FY'78.

TABLE 7b

MODIFIED LEVEL BUDGET OPTION
(by Fiscal Years in Millions of Dollars)

Subprogram[a]	1977	1978	1979	1980	1981
Health Effects	31.3	30.7	28.2	28	28
Ecolo. Proc. & Effects	19.0	16.8	16.3	16	16
Transp. & Fate of Poll.	12.7	12.7	12.2	12	12
Waste Management	14.5	18.5	18.5	19	19
Water Supply	13.2	15.2	14.7	15	15
Environmental Mgmt.	1.6	1.6	1.6	2	2
Renewable Resources Ind.	6.1	5.6	5.6	6	6
Minerals, Proc. & Mfg. Ind.	12.4	12.4	11.4	12	12
Energy Ext. & Proc. Tech.	25.4	24.4	24.4	24	24
Energy Cons., Util., Tech. Assess.	32.7	30.6	30.6	31	31
Energy Health & Eco. Eff.	35.2	39.2	35.2	35	35
Monitoring Tech. & Eq. Dev.	10.8	10.5	10.5	11	11
Quality Assurance	5.4	5.4	5.4	5	5
Tech. Support[b]	12.7	11.5	11.5	11	11
Toxic Substances Research[c]	1.4	1.4	8.4	9	9
Total[d]	234.4	236.5	236.5	237	237

[a] Subprogram budgets exclude toxic substances research, which is highlighted separately for this presentation.

[b] Includes Energy Technical Support.

[c] This is not a subprogram, but the total for toxic substances research in all subprograms. The latter three years represent a potential reprogramming in response to P.L. 94-469, if ORD totals are maintained level.

[d] Does not include program management, miscellaneous overhead, and special transfers which totaled $24.9 million in FY'78.

TABLE 7c

GROWTH BUDGET OPTION
(by Fiscal Years in Millions of Dollars)

Subprogram[a]	1977	1978	1979	1980	1981
Health Effects	31.3	30.7	41.1	46	50
Ecolo. Proc. & Effects	19.0	16.8	19.7	21	22
Transp. & Fate of Poll.	12.7	12.7	15.6	18	19
Waste Management	14.5	18.5	23.1	27	30
Water Supply	13.2	15.2	17.4	18	20
Environmental Mgmt.	1.6	1.6	2.2	3	3
Renewable Resources Ind.	6.1	5.6	6.8	8	9
Minerals, Proc. & Mfg. Ind.	12.4	12.4	13.1	14	14
Energy Ext. & Proc. Tech.	25.4	24.4	25.8	28	29
Energy Cons., Util., Tech. Assess.	32.7	30.6	32.1	34	35
Energy Health & Eco. Eff.	35.2	39.2	41.1	43	45
Monitoring Tech. & Eq. Dev.	10.8	10.5	12.4	14	15
Quality Assurance	5.4	5.4	6.6	9	11
Tech. Support[b]	12.7	11.5	12.0	13	13
Toxic Substances Research[c]	1.4	1.4	8.4	23	23
Total[d]	234.4	236.5	260.3	319	346

[a] Subprogram budgets exclude toxic substances research, which is highlighted separately for this presentation.

[b] Includes Energy Technical Support.

[c] This is not a subprogram, but the total for toxic substances research in all subprograms. It is reported separately this year in response to P.L. 94-469.

[d] Does not include program management, miscellaneous overhead, and special transfers which totaled $24.9 million in FY 78.

Section II

THE PROGRAMS

Section II of this report addresses itself to the description, direction, objectives, and outputs of the ORD Research Programs for the period of FY'77 through FY'81. For detailed information on the FY'77 programs, readers should refer to the "ORD Program Guide Fiscal Year 1977" (EPA 600/9-76-029) which complements this report.

The meaning of criteria as used herein refers in general to those ORD judgemental values, limits, etc., arrived at through scientific studies, experiments and or information gathered through the auspices of the ORD organization. In general the term criteria is not used to infer that ORD criteria are necessarily those which the Agency will formally issue as its basis to support its regulatory responsibility, as the Agency may often include additional information and considerations other than the view of the research scientist.

The term technology, and more specifically control technology is also broadly used and should not be considered to solely signify engineering "hardware" research, as some interpretations tend to do. Wherever possible, and where justified, there has been a specific attempt to separate the general technology effort into various components i.e., control technology ("hard") versus technology assessment ("soft") to allow the reader insight on the emphasis of effort.

Criteria outputs from ORD scientific research efforts are generally applicable to the establishment of EPA ambient quality regulations, and in a few cases to effluent or other regulations. In some cases ORD criteria may also establish desirable targets for the technological research programs which develop control equipment, methods or systems to achieve the criteria values for specific and general cases. Technology research, however, is primarily directed toward the development and demonstration of technology to support the Agency in setting control regulations based on technological capability.

The subprograms discussed in Section II are discussed in terms of the low level budget option of resource funding (Level Budget Option - Section I). Additionally, the major subprograms also include a discussion of potential subprogram growth areas where additional research for the five year period is described. This represents the additional research which would be desirable to undertake to effectively meet current EPA legislative mandates, to adequately address recently passed legislation, and to provide at least a meaningful start on research to develop anticipatory cabability. These potential activities would be undertaken in the event the Growth Budget Option resources summarized in Section I are appropriated in FY'78.

While science and technology programs are oriented to impact Agency regulatory decisions related to the formulation of numerical values of ambient quality and effluent/emission limitations, environmental management research develops action alternatives for the implementation of regulations to meet ambient quality goals. In this sense environmental management research impacts the formulation of regulatory strategies for environmental protection. In the broad sense "environmental management" covers socio-economic, integrated assessments, and environmental management activities, respectively, within the OHEE, OEMI, and OAIWU programs. Each Office tailors these forms of management research to suit the needs of the Offices to produce comprehensive and coherent interpretations of their research outputs as they apply to formulating an implementation strategy.

HEALTH AND ECOLOGICAL EFFECTS PROGRAM

The Health and Ecological Effects Program is fundamental to EPA's responsibility to set criteria. Scientific information on the effects and impacts of pollutants on human health and ecosystems and their behavior in the biosphere is essential in development of environmental regulations. The relationships between pollution source discharges and desirable ambient quality must be determined. To develop the necessary information, the program is divided into four major subprograms, three of which (Health Effects, Ecological Effects and Processes, and Transport and Fate of Pollutants) provide inputs to the fourth (Criteria Development and Socio-economic Studies).

The goal of the "Effects" Program is to develop information for establishment and reevaluation of water and air quality criteria, ocean disposal criteria, pesticide registration guidelines, effluent standards for toxic and hazardous materials and radiation standards.

Research must continue in the Health Effects Subprogram on criteria pollutants with set ambient air quality standards to enable a continuing reevaluation of such standards. Such research will, however gradually be reduced over the next five years while research (i.e., developing dose-response information) on noncriteria pollutants, especially sulfates, nitrates, and respirable suspended particulates will be acclerated. A comprehensive inhalation toxicology and biomedical data base will also be developed to ascertain health risks of emission products from catalytic converter-treated auto exhaust and potential catalyst attrition products such as sulfuric acid, sulfates, carbon disulfide, hydrogen sulfide, palladium, platinum and aluminum oxide. Research on environmentally-induced carcinogenesis has recently begun and will focus on quantitative assessment of environmental levels of carcinogens and associated risk factors. Efforts to identify chronic effects of exposure to specific environmental chemical agents (multiroute pollutants) will be expanded.

Research on health implications of land disposal of wastewaters and sludges and the effects of aerosols containing bacteria or viruses emitted from treatment plants will continue to receive high priority. A related subprogram, Water Supply, supplements research in the Health Effects Subprogram with additional funds. This research focuses on health effects of contaminants found in drinking water. Details of this research are discussed in the Water Supply Subprogram.

Health effects research on pesticides will increasingly receive emphasis and will provide necessary support to regulatory and control functions of EPA in regard to risks of pesticides to population groups in general.

Toxic substances research in health and ecological effects initiated in prior years will continue and will be directed specifically to support the implementation of the Toxic Substances Control Act of 1976 (TSCA).

The research effort to identify biological effects of electromagnetic radiation will continue at a constant level of effort.

The Ecological Processes and Effects Subprogram will continue its current effort to evaluate criteria air pollutants effects on agricultural and forest plants, and to develop water quality requirements for representative organisms. It will include a greater empahsis on evaluation of whole ecosystems and on developing ecological models with minimal information requirements. However, the need to determine criteria for specific pollutants will continue.

The Ecological Processes and Effects Subprogram researches not only effects of pollutants on ecosystems and their components, but also researches effects of ecosystems on pollutants. Such considerations are important determinants of how quickly pollutants will be transformed into harmless materials, persist and accumulate to dangerous levels or be changed into more harmful materials than the parent substance. This research information on the fate, transport, and ecosystem impact of specific pollutants is necessary to support environmental quality criteria development and pesticide registration.

Information on the fate and transport of pollutants in the biosphere is needed by EPA's regional offices and states to implement standards, basin planning, and wasteload allocations. Specific emphasis will be on transport and fate of metals in soils and plants; coupling nonpoint source loading models to basin water quality models for use in assessing water quality impacts of both nonpoint and point sources; development of pollution loading functions by source with appropriate user manuals; assessment of the air transport and alteration of sulfates on a regional and sub-continental scale; research on the formation and transport of non-regulated pollutants; and on analysis of data accumulated from long-term surveillance projects.

Emerging problems, such as those of fluorocarbons and other potentially hazardous substances, will receive increased attention. Research will focus on the long-term pollutant loading capacity of the environment globally, regionally, and locally; the likely effects of different pollutant load levels; and on predictive capability for forecasting loca, regional, and sub-continental environmental quality under varying pollutant loadings and environmental conditions.

Funds from ORD's Energy/Environment Program supplement much of the research in the Health and Ecological Effects Program. In some cases such funding allows for more intensive research in activities already planned by other programs. In other cases, research activities with a much broader scope are made possible. The comprehensive EPA-coordinated Energy/Environment Program is discussed later.

Another emphasis in Health and Ecological Effects Program will be on socioeconomic assessments. This work will focus on assessment of health and welfare benefits of pollution abatement; development of methods for predicting and evaluating pollution problems related to exposure; and economic impact assessment. Emphasis in benefit studies is expected to be on pesticides, toxic substances, and drinking water. Ad Hoc studies will also be conducted on specific EPA issues as they arise.

Health Effects Subprogram

The Health Effects Subprogram is divided into five categories as follows:

- Air Quality
- Water Quality
- Pesticides
- Toxic Substances
- Radiation

Research efforts in all categories seek to identify and quantify the human health risk from exposure to pollutants relevant to the categories. This assessment is generally made by systematic research which includes animal exposure experiments (toxicology), clinical (controlled human exposure) and epidemiological (population) studies. The net outputs from the research are dose-response relationships which are used to estimate risk factors and which aid in the establishment of ambient environmental criteria. The latter results in Agency ambient regulations. Such regulations are then considered in conjunction with emission and effluent regulations and applied for pollution control. Where such control may not afford the attainment of ambient standards, other factors are considered to achieve desired regional quality goals.

Over the past several years, many significant accomplishments have been made in the health effects area. Some of the major ones are summarized below:

The air health program has been instrumental in identifying pollutants of potential concern to human health. Research emanating from the air epidemiology program, for example, gave early clues that "sulfates" might be a pollutant of health effects concern and to the potential need for a short term standard for nitrogen dioxide. A series of studies also was completed which indicated an association between exposure to nitrogen oxides and ozone and lowered resistance to infection.

A program on pollutants associated with catalytic converters was initiated to collect baseline data for trend investigations of roadside levels of sulfates, catalytic attrition products, and other mobile source air pollutants. Compilations of results obtained from catalyst-related work in ORD and in the Office of Air and Waste Management are expected to contribute to EPA's assessment of the health and environmental implications of mobile emissions and measures to control them.

The health effects program has contributed significantly in other aspects of mobile and stationary source pollution, including contributions to EPA's position on airborne lead and preliminary assessments of potential effects of fuel additives which may be used as substitutes for lead. The design and development of hardware for a system for intensive environmental and human health characterization was completed. This system includes mobile units equipped to measure air quality and characterize exposure and units equipped for clinical evaluations of human health to provide EPA with a unique field capability for assessing exposure-effects relationships between environmental pollutants and human health.

Air Quality--

The objective of the air exposure health effects research program is to provide the Agency with assessments of the health effects that result from public exposure to various air pollutants as stipulated in the Clean Air Act.

The air health program is divided into five major research areas which will be discussed separately: criteria pollutants, non-criteria pollutants, automotive emissions, multi-route (non-pesticides), and environmental carcinogens. The automotive emissions area is unique. This research is carried out by several laboratories under different Laboratory and Office Directors, the various aspects of this research are consolidated under a single management to establish a single point of control. The automotive emissions narrative thus includes the research on emissions characterization, atmospheric monitoring and modeling, as well as health effects.

Criteria Pollutants--Research is undertaken to evaluate the adequacy of existing Ambient Air Quality Standards (AAQS) for the protection of human health as well as to provide new information for refining the existing AAQS criteria. This objective is directed toward building on information which has become available since the original criteria for sulfur dioxide, total suspended particulates, carbon monoxide, photochemical oxidants, hydrocarbons, and oxides of nitrogen were complied. Priorites for the pollutants to be studied in descending order are: nitrogen dioxide, oxidants, particulates, sulfur dioxide and carbon monoxide. Emphasis is being placed on those studies relating to short-term intermittant exposures to oxidants and nitrogen dioxide, low level exposures to oxidants, and the use of behavioral and neurobehavioral responses as indicators of adverse effects from exposures to these air pollutants.

Efforts will continue toward identification of populations most at risk to AAQS pollutants and determination of appropriate health effects end points. Primary effort will involve the application of sophisticated physiological response methodologies for determining cardiopulmonary, atherogenic and behavior effects resulting from experimental human exposures to oxidants. Another important segment of this effort is the assessment of the effects of exposures to ambient air pollution on pulmonary development and lung function in children. Since exposure assessment is another means of identifying populations at risk, a minimal effort will continue to improve methodology for characterizing human exposure to air pollutants in health study areas.

Research is also being conducted to determine the effects from exposure to combinations of AAQS pollutants. Previously developed in vitro animal model systems are being applied to ascertain and quantify the effects of pollutant exposures on pulmonary defense mechanisms as they relate to bacterial infections, viral infections, and chronic pulmonary disease. Clinical human exposures are also required to evaluate the effects of acute and subacute exposures to multiple pollutants on the cardiopulmonary and neurobehavioral systems. Population studies are being conducted to assess the exposure of adults or adolescents to photochemical oxidant pollution. Effects of concern include chronic, as well as short-term intermittent exposures. A capability has also been developed for determining excess mortality in the event of the occurrence of air pollution episodes. Interim reports will be produced in FY 78 and 81, and a final report on metabolic and immune responses to ozone and nitrogen dioxide will be produced in FY 81. A final report on effects of photochemical oxidants on persons with and without chronic respiratory disease is scheduled for FY 79. A final report on chronic bronchitis in smokers in high and low oxidant exposure areas will be published in FY 80.

As a result of the above activities, the accumulated health data from the population, clinical and toxicological studies are analyzed in association with the pollutant exposure data with due regard to other independent environmental variables, and presented as reports indicating "worst case," "best judgement" estimates for pollutant exposure levels associated with each observed health effect. These reports, along with other pertinent scientific literature, are incorporated into revised air quality criteria documents.

Non-Criteria Pollutants-- The health effects research in the air non-criteria pollutants area has been focusing on sulfates, since some epidemiologic studies indicate that a statistical correlation exists between sulfates and adverse health effects. A health effects research program is underway to develop and obtain data from biological screening systems, determine the metabolic pathways and target organs, understand response mechanisms, and establish dose-response data. Within each area, consideration is given to the various sulfate compounds and their relative toxicities, cation-anion relationships, compound physical characteristics such as size and bioavailability, concentration and time duration of exposure, and combined or synergistic effects with other pollutants. From experimental results obtained to date, the sulfate research program has recently focused its effort on determining whether ambient levels of sulfuric acid, ammonium bisulfate, ammonium sulfate, and sulfites will show adverse health effects in humans. Toxicology studies are directed toward evaluating the comparative toxicity of the above strong acid, weak acid, and neutral sulfate aerosols using in vitro testing models and whole animal studies. The results of these tests will provide a data base for developing a dose-response curve from animal exposures to sulfates. Other toxicologic experiments will be addressing the development of better health indicators for epidemiologic studies. The exposure regimen for the toxicologic research will include both short-term and long-term exposures in order to assess both acute and chronic effects in a variety of animal species.

The clinical studies research program on sulfates will be focused on short-term exposure to concentrations approximating ambient or occupational exosure conditions. The objective of these studies will be to determine the level of short-term exposure at which biochemical, physiological, and behavioral responses are observed in human subjects. The principal aspects of the epidemiologic studies will be the characterization of human exposure patterns and the use of appropriate health indicators to determine whether there are relationships between ambient levels of the various sulfate compounds and adverse health effects.

Automotive Emissions--Automotive Emissions Research begun in FY 1974, was an outgrowth of concern over sulfuric acid emissions from automobiles equipped with oxidation catalysts. In addressing this issue, the Agency decided that the program should take on the broader objective of assessing the effects on the public health of the various unregulated pollutants that might be emitted from mobile sources equipped with emission control devices and not limit the program to studying effects from sulfuric acid emissions alone. In FY 1975, sufficient resuources became available to begin the research effort. The two areas that received immediate attention where sulfuric acid and platinum. The sulfuric acid research focused on characterizing the tailpipe emission products, monitoring and modeling in the vicinity of roadways, and establishing a health effects data base. Because the oxidation catalysts that were being used employ platinum, similar studies were begun on platinum.

The major efforts to date on sulfuric acid include the development of analytical methods for measuring sulfuric acid in the exhaust and ambient air, the determination that sulfuric acid is emitted as an ultrafine aerosol, and the prediction of in-roadway and roadway worst-case ambient concentration of sulfuric acid. Much effort continues to be focused on characterizing the sulfuric acid emissions profile over the life of the catalyst to help in developing emission factors. A pilot study is now underway to assess the commuter exposure to sulfuric acid.

In the health area, three sets of experiments have begun. The first set is evaluating the effects of aged sulfuric acid on animals and man. The second set is focusing on the effects of ultrafine sulfuric acid on animals and man. The third set is directed at exposing animals to the entire exhaust of catalyst equipped automobiles.

The experimental work on platinum is in its final phases. Data that has been collected for establishing baseline environmental platinum indicate that it is emitted in the large particulate fraction only and in negligible quantities. The only significant additonal work to be performed on platinum will be a battery of mutagenic and carcinogenic tests. Based on the data now available, platinum emissions are not believed to be a pollutant of concern.

The catalyst research effort has prepared a large number of scientific assessments on various potential emissions products from catalyst equipped automobiles. Some of the important ones include asbestos, carbon disulfide/carbonyl sulfide, manganese, molybdenum, nitrosamines, halogens, lead, ethylene dibromide, hydrogen cyanide and bromide, methyl mercury, ruthenium, and nickel. This type of effort is an ongoing requirement since manufacturers are continuing to develop different catalyst mixes which produce different emissions and which, therefore, require a public health evaluation.

In the monitoring area, work is continuing on collecting and analyzing data on in-use catalyst vehicles, especially the performance of the catalyst over time and whether the catalyst is emitting significant quantities of other pollutants, the unregulated pollutants. Another effort is directed to validating and improving the carbon monoxide dispersion model necessary in developing state implementation plans and transportation control strategies in urban areas.

Considerable work is being performed on manganese, a possible fuel additive. Research is now being conducted to determine the effect of manganese on the operation of the catalyst and the changes in emissions that might result. A set of health effects studies will soon begin to study the acute and chronic effects from manganese emissions.

Since the three-way catalyst system is gaining interest among manufacturers, additonal work is being conducted on estimating hydrogen cyanide (HCN) levels produced when the emission control system malfunctions. These experiments will provide the data for use by the health researchers in determining if the HCN poses a potential health hazard to the public.

In the near future, research in this automotive emissions area will continue to concentrate on sulfuric acid, manganese, and HCN associated problems from catalyst systems. But as manufacturers request certification on new control devices, new research efforts will have to begin to characterize, monitor, and model the health effects issues that will arise from these new systems.

Multiroute Pollutants--Many environmental pollutants are differentially distributed throughout the various environmental media and are, therefore, capable of reaching man via multiple routes of exposure, primarily air, water and food. Relevant health effects research must be aimed at defining populations at risk, health effects end-points, and exposure-effect relationships.

A major emphasis in this program is the identification of high exposure populations and the determination of the relationship of established human body burdens to the multiple route environmental exposure and observed health effects. Human tissue burdens will be determined and related to environmental exposures for pollutants representing a number of metallic elements as well as non-halogenated organics considered to be of potential health concern. Analytic methodologies will be standardized and, where appropriate, applied to autopsy tissue samples as well as blood, hair, and urine samples obtained from live subjects non-occupationally exposed to the subject polluant(s). Environmental media samples will also be collected and compared to tissue burdens. To assess the contribution of the various exposure routes to the total body burden.

Health effect end-points and dose-effect relationships will be studied covering both inorganic and organic pollutants. Initial emphasis on inorganic pollutants is directed toward lead, cadmium, selenium, arsenic, and manganese. Relevant studies include the neurophysiologic evaluation of children with asymptomatic lead burdens; effects of chronic, low-level cadmium exposures on hypertension; influence of age on whole body retention of ingested manganese, selenium, and arsenic; and teratologic, reproductive, neurophysiologic, and behavioral effects of chronic, multi-generation exposure to manganese.

Initial emphasis on organic pollutants will be determined by priorities established via implementation of the Toxic Substances Control Act of 1976. Health end-point and dose-effect information could be obtained via studies for assessing immunologic, behavioral, teratogenic/genetic, mutagentic, and cytotoxic effects. In vitro screening methods would also be applied to identify suspect carcinogens.

The more general approach would be to consider kinetic, distribution and biochemical studies; neurophysiologic and behavioral studies; teratologic, reporductive, genetic and pathologic studies; and screening for suspect carcinogens.

Recently, a growing interest has been developing, on a national and international basis, concerning biologic monitoring and environmental specimen repositories. In support of this potentially useful tool for environmental assessment, current efforts have been directed toward the development of protocols for accurate and reproducible procedures concerning tissue sampling, transport, storage, and analysis. Future activities would extend the above program, develop guidelines for the operation and maintenance of a National Environmental Specimen Bank, and initiate a "pilot" bank effort for determining the feasibility and usefulness of such a system.

Environmental Carcinogens--Research on cancer and carcinogenic agents has long been underway in many agencies and research organizations. There is a growing awareness that environmental agents may play an important role in the incidence of human cancer. However, information on the distribution and levels of potential environmental carcinogens and on the extent to which the public health may be at risk from such agents is still rather limited. In FY 1976, EPA initiated an effort to develop a systematic approach for assessing the impact of environmental carcinogens on the incidence of cancer in the general population.

With the overall objective of developing an effective system for the study of environmental carcinogens, this effort would enable ORD to provide the Agency with information on exposure/effect relationships for several different cancer types and geographic areas, on estimates of risk for several cancer types, on the importance of cofactors, and procedures for more accurate estimation of individual exposure to environmental agents. This research will necessitate phases of intense data collection which, in turn, will enable us to generate a consolidated data repository for the United States on a country and/or Standard Metropolitan Statistical Area (SMSA) basis. This would allow easy data accession to develop correlations and to evaluate interactions between demographic, monitoring, emission source and human disease factors. In addition, effort will be devoted to minimizing the uncertainty involved in extrapolating from animal studies to man.

Because of this Agency's special abilities and expertise in characterizing and monitoring environmental exposures, this program is unique from other cancer research in that if focuses on the quantitative assessment of environmental levels of carcinogens and estimations of risks to human populations. An important feature of this program will be the consolidation and coordination of the many data bases currently existing in other agencies to assure optimal utilization of resources and expertise.

The program will consist of a series of interrelated environmental monitoring, exposure assessment, and retrospective epidemiology studies designed to determine the reasons for high and low cancer mortality rates in select geographic areas. The principal thrust of this program will be ultimately to identify the significance of environmental carcinogens to human cancer incidence via an intensive monitoring program to assess media transport, inter-and intra-media transformation, current exposure levels and population dose, and past exposures for man made and natural carcinogens which may affect the general population. The coordinated data base obtained and correlations developed, including information on critical pathways of exposure to humans, will be applied to develop a model that will have general applicability for carcinogen exposure-dose assessment and to institute a pollutant-oriented monitoring system. These will be applied and validated in another set of areas with low and high mortality rates for a specific cancer type and possibly in an area with different exposure levels. It is also planned in the outyears to evaluate in vitro screening methods and determine their applicability for agency identification for new potential carcinogens, to define what type of animal testing will be required to supplement in vitro screening techniques, and to conduct a feasibility study on possible acceleration of cancer latency periods in test systems.

Water Quality--

The objective of the Water Quality Health Effects program is to determine the health implications of existing municipal control technology for treatment and disposal of wastewater and sludge as well as forseeing any health risks that might be associated with new technology. The research currently focuses on health implications of land application of wastewater and sludge. Other areas of study include health effects associated with wastewater treatment plants and development of criteria for fresh and marine recreational waters.

The water quality health effects research program will focus on determining the direct and indirect health effects resulting from the treatment and disposal of wastewater and sludge. This effort includes, in order of priority, the following described studies.

First is the determination of health effects associated with the land treatment and disposal of wastewater and sludge, and the development of necessary criteria for the safe implementation of those practices. Current practices result in approximately 60 percent of the municipal wastewater sludges produced being placed on or in the land. PL 92-500 and Agency policy require that land application of wastewater be considered as a viable alternative to conventional wastewater treatment plants. This emphasis on the use of land places a responsibility on the Office of Health and Ecological Effects to ensure that the methods used do not result in the creation of health hazards. Pathogens, toxic organics and trace metals present in wastewater and sludge could reach man via the air, water and/or food route, when wastewater or sludges are applied to the land. Information derived from health effects data on exposures to these substances will determine the degree of treatment needed before application to the land, the type of crops or forage allowable without endangering the public health and the extent of a buffer zone around application sites, if such is necessary.

Necessary health effects information is being developed to assure that the public is protected from hazardous pollutants emitted during the operation of conventional wastewater treatment plants. Aerosol emissions from secondary treatment facilities could present a health hazard to neighboring populations. Studies are designed to determine whether pathogens and toxic substances are transported via the aerosol route. Corroborative epidemiological studies will determine whether corrective measures need to be taken.

Quantification of health effects associated with the disposal of wastewater into the aquatic environment is projected. Discharge of effluents into receiving waters affect human health through primary contact recreation, aquatic food and drinking water. The quality of water needed for these uses will, in turn, determine the degree of treatment required before the safe discharge of such effluents.

The drinking water human exposure route is discussed in the Water Supply Subprogram under Public Sector Activities Program. Microgiological criteria are being developed for fresh and marine recreational water as well as shellfish growing waters. Such criteria will, in turn, be translated into disinfection requirements necessary for the protection of public health.

Pesticides Health Effects--

The pesticides health effects research program supports the Agency's activities with respect to meeting legally mandated responsibilities for pesticides, which include registration, label reviews, hazard classification, and tolerance setting. During this five-year period, particular emphasis will be placed on studies needed for the Reregistration Process and the Rebuttable Presumption Against Registration Program (RPAR). The proposed research program will provide supplementary data and missing information as well as checks on the validity of available information. However, research will continue on important pesticides now in use and on "new generation" pesticides and substitute chemicals. A major effort during this five-year period will be directed toward providing technical support to the Office of Pesticide Programs (OPP), Enforcement and Regional Offices. Expertise in pesticide research is required as input to administrative decisions pertinent to the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), also known as the Federal Environmental Pesticides Control Act (PL 92-583).

Pesticide research supported under FIFRA will also be available for use by other segments of the Agency interested in regulating pesticides under different legislative authorities. For example, results from the program can be used to support toxic effluent standards, issuance of permits, and water quality criteria for fresh, estuarine and coastal waters under the Federal Water Pollution Control Act (PL 92-500). The information will also be used in support of regulations under the Safe Drinking Water Act (PL 92-523).

In the five year health effects pesticide research program, toxicological studies will be conducted to determine the acute, subacute and chronic effects of pesticides on mammals, the potential effects of "new generation" pest control agents, such as biological agents like viruses, bacteria, and sex attractants, the identification of pesticide metabolites, and the distribution and effects of pesticides and metabolites in animal tissues. Studies will also address biochemical effects on metabolic activity, reproductive function and central nervous system function, and the potential for causing gene mutations and cancer.

Inhalation toxicology studies will continue to assess the importance of inhalation exposures to pesticides as compared with ingestion and skin contact. These studies will yield determination of the acute effects of pesticide aerosols of controlled particle sizes, and measurement of the distribution of the parent compound and its metabolites in body tissues, urine and feces. Along with these animal studies will be the evaluation of acute and chronic human exposure to pesticides, their residues and their metabolites. Indices of effects to be examined inclued mortality, clinical signs of poisoning, hemologic factors, reproduction and cancer incidence. The pesticides which will be evaluated are those identified by the Agency to be of greatest concern. The emphasis will be on those compounds identified as "problem compounds"; those in the "restricted use" category, and for new products or for new use registered compounds. These studies are done in conjunction with OPP. In addition, the human safety of "new generation" pest control agents such as insect viruses, pathogenic bacteria, chemosterilants, attractants and hormones will be evaluated.

The development and validation of new toxicological methods and test protocols, and the development and application of analytical methods to detect these agents in environmental samples and human tissue will continue to be a major part of pesticides health effects research. In the area of analytic techniques, attention will be given to developing a sensitive, specific detector for pesticides containing chloride, sulfur and/or nitrogen; an efficient system for collecting and determining pesticides in air; and analytical methods for determining dioxins in tissues, environmental media, and pesticide formulations. Other objectives include completion of a laboratory manual which includes methods for analysis of pesticides in wastewater, the use of multiresidue analytical procedures for carbamate and organophosphate pesticides, and establishment of standardized procedures for identification of insect viruses in tissues.

Recently developed in vitro systems for mutagenicity, teratogenicity and carcinogenicity will be refined and utilized. This test system constitutes an integrated battery of methods which are applicable in the screening of pure chemicals as well as complex environmental effluents. These systems are of value both in detecting potentially hazardous materials and in establishing priorities for testing suspected substances by conventional (whole animal) toxicological methods.

The compounds and formulations which will be evaluated are those identified by OPP to be of greatest concern. Tentatively, within this framework, the priorities will be on those compounds identified as problem compounds, those in the restricted use category, and for new products or for new use registered compounds. This may entail a shift in the pesticide toxicology research from the persistent chlorinated hydrocarbon compounds to the biodegradable materials, such as the organic phosphorus and carbamate compounds, and the "new generation" biological pesticides. The top priorities in pesticide research are also dictated by the data deficiencies observed during the literature review and in those candidates for which RPAP has been cited.

Work by the National Center for Toxicological Research (NCTR) will continue the development and validation of new toxicological methods to evaluate exposure-effects relationships of potential new pesticides. These studies are long-term, low-dose in design and cover specific compounds of interest to EPA, especially as it relates to carcinogenicity, mutagenicity and teratogenicity.

Toxic Substances--

The toxic substances research discussed in this section is part of a program initiated in prior years. It has not yet been made a specific part of the overall implementation of the Toxic Substances Control Act of 1976 (TSCA), but it is relevant to it. As EPA moves to implement TSCA in the current and ensuing years, this program will be directed specifically to supporting the needs in that area.

Most toxic substances reach man through several media rather than through a single main source, such as water or air. In Fiscal Year 1977-1981 research on these non-pesticide environmental pollutants from multiple exposure routes is to be directed toward four objectives. First, it will be directed toward determining potential hazards to human health. Second, research methods will be developed for rapidly screening large numbers of potentially toxic substances to determine their relative toxicity. Third, rapid methods will be developed with sufficient sensitivity to measure clear quantitative biochemical effects resulting from low-level concentrations to which the human population is exposed. Fourth, by using basic physical constants and seeking similarity in molecular structures of compounds, research is aimed toward development of methods which will predict persistence and disposition of the substances in the environment.

Research studies are being carried out in animal model systems to evaluate the toxic hazard to humans of selected high priority toxic materials. These studies emphasize acute toxicity through studies of oral, dermal, and respiratory exposure routes, and possible long-term effects through evaluations of teratogenic and mutagenic potential. A priority need is the development of improved in vitro pre-screening methods and the operation of a screening program for determining by short-term tests the potential for chronic effects. Such work will enable development of research priorities for substances having suspected high toxicity and requiring longer term research. Polychlorinated biphenyls (PCB's) are among the priority compounds now under test for the EPA Office of Toxic Substances (OTS). Additional compounds will be selected from OTS Pollutant Priorities list and, when available, from the TSCA-required initial priority list of fifty compounds, as resources permit.

Human exposure studies are essential in the correlation and extrapolation of animal experimental data to man. Research work will continue throughout the five-year planning period with clinical and epidemiological studies to measure human exposure levels in environmental and occupational situations. Results will be utilized to develop a predictive model for human risk assessment. Other objectives continuing throughout the planning period include determining health effects of asbestos-like amphibole fibers; improving the reliability and sensitivity of bacterial mutagenesis as a screening test for carcinogenesis; and evaluation of saliva as a indicator of exposure to toxicants.

Research work to be completed during the Fiscal Year 1977-1981 period includes the study of interaction of chemical carcinogens with pesticides and the development of an in vitro test system for evaluation of teratogens. These efforts will be followed, when appropriate by the development of tests validating the in vitro rapid screening method results and correlating tests in lower life forms with those to be expected in man. Validations are to be sought through study of biochemical, metabolic, and immunologic systems. In the area of chronic effects of low-level chemical toxicant methods and testing, EPA jointly supports with the Food and Drug Administration the long-term work of the National Center for Toxicological Research (NCTR).

Radiation--

The establishment of guidelines for environmental levels of non-ionizing radiation to which the public is exposed is an EPA responsibility. Because of concern about potential biological hazards of electromagnetic radiation (EMR), the Office of Telecommunications Policy (OTP), Executive Office of the President, initiated and is coordinating a multi-agency program to assess the hazards of non-ionizing radiation. EPA has been assigned the conduct of health effects research on EMR frequencies of potential environmental consequence. This accounts for about fifteen per cent of all Federal efforts in non-ionizing radiation research.

Data emerging from EPA's on-going research program is beginning to confirm existing international findings of harmful effects at chronic, low-level exposures. These findings, if substantiated, would suggest that the current U.S. occupational guide may be too high for the use as a departure point for providing environmental guidance that is adequately protective of public health.

Potential Subprogram Growth Areas--

The previous Health Effects Subprogram descriptions have identified five-year efforts based on the level budget option summarized in Section I. Moderate program growth as indicated in Section I would permit more timely achievement of health effects research objectives. Specific output delays would be reduced, some new efforts could be started, and better use would be made of facilities, such as the new Chapel Hill Health Effects Clinical Experimental Facility which will become operational in FY'78.

Accordingly, a supplemental growth budget option is considered desirable and would prevent incompleted work terminations and allow the other current areas of research to grow to a meaningful conclusive point and the initiation of new research relevant to new legislation and Agency priorities.

Air Quality research could accomplish the following tasks:

. Conclude lead effects determinations in children.

- Increase scope of oxides of sulfur and non-criteria pollutants at the clinical level and restore the epidemiological scope to the five cities necessary to assure statistical validation.
- Reinstatement of toxicological support of above work.
- Conduct sulfate chemical exposure research on susceptable subjects.
- Prevent the curtailment of automobile emissions assessments required for OMSAPC certification review, and permit clinical exposure to surfuric and aerosols to conclude.
- Prevent slippage on current target dates for research on metals and toxic chemicals reaching man by multiple routes.
- Validation of the experimental model to predict toxic effects to man from animal exposures.
- Prevent the elimination of prospective epidemiology and other monitoring support efforts in the carcinogen research area.
- Reinitiation of neurobehavioral, cardiovascular, metabolic, and immune response from experimental human exposure to ozone and other oxidants.
- Initiate diesel engine emission effects research to accommodate OMSAPC's information needs.
- Development of the integated system approach to address and link all pertinent major research planned in the carcinogen module (See Section III).

In the Water Quality category, the shellfish-growing program would be restored to result in FDA participation. A combined health-ecological study on the fate of microbial indicators and pathogens in the marine environment would be initiated. Determination on the adverse effects from pathogens, toxic metals and organics of land treatment and disposal of wastewater sludges would be made. The impacts on neighboring populations from secondary treatment plants and wastewater irrigation could also be determined, as well as the uptake of refractory organics and metals into food chain crops.

In the pesticides category the number of pesticides originally identified for study could be expanded. Work in animal modeling and pesticide reference repository would be reinstated, and the farm workers exposure investigation underway would be maintained. An additional number of widely used and some "new generation" pesticides would be tested for acute and chronic toxicity and carcinogenisis resulting from long-term expsoure. This effort would develop animal models to assess the actions of the compounds and would allow for the subsequent development of Human Dose/Response Models.

With respect to toxic substances, work in areas relating toxicants to immulogic response and validation of methods and data correlation in animals and man would be reinstated. In direct support of the new TSCA legislation, one or more of the following work areas could be initiated: expansion of analytical capability to support the Office of Toxic Substances, Regions, and Office of Environment; research on principles to improve toxicity test methods; expanded development of short-term methods to assess chronic toxicity; development of chemical effects screening methods; and other TSCA relevant research as described under the toxics module in Section III.

In the radiation category reinstatement of cytogenetic and immunologic effects research and continuation of low-level electromagnetic radiation (EMR) exposure effects would be done. The continual upgrading and refinement of microwave dosimetry techniques and exposure systems could be maintained. A continually increasing emphasis on the neurophysiologic and behavioral effects (considered the most sensitive indicators) from chronic exposure will develop in addition to a more comprehensive program on the study of teratogenic, cytogenetic and immunologic effects. As the most sensitive biological indicators become better defined, studies would be extended and expanded which utilize EMR as a co-factor in multiple stress investigations, and in FY'82 epidemiologic investigations on selected populations will be initiated.

Ecological Processes and Effects Subprogram

Ecological processes and effects research provides EPA with a base upon which environmental criteria, standards and regulations may be set. Ecology is a scientific discipline that determines the pattern of relationships between organisms and their environment. Ecological research provides a base essential to developing water and air quality criteria, pesticide registration, ocean discharge criteria, and effluent standards for toxic and hazardous materials.

Several fundamental features of ecological research should be emphasized in connection with EPA's regulatory responsibilities. Problem identification, such as the disclosure that a pollutant causes human cancer, implies regulatory consideration and also generates a plethora of environmental questions concerning the pollutant. Consequently, human health effects are related to the ecological framework, as the following questions suggest:

- How does the pollutant behave in the environment and particularly how does it gets to the human subject?
- Is the pollutant accumulated or concentrated by human food organisms? What is the effect of the pollutant on these and other nontarget organisms?
- Does the pollutant have significant effects on ecological systems that support human uses and what is a significant effect?

- What features of the fate, effects or transport of the pollutant allow for its control or may be useful for regulatory deliberations?

- What are secondary effects of abatement or regulatory strategies?

- How available is the pollutant in the natural environment?

The above questions illustrate the scope and purpose of ecological research: that of assessing and predicting the extent of environmental pollution damages, limitations of the ecosystems to absorb pollutants, and their indirect effects on human health and welfare.

Ecological research activities respond to EPA's administration of environmental law and to changes in these laws. For example, P.L. 92-500 represents a major new direction in water quality regulation--a switch in emphasis from receiving-water standards to effluent standards. This change requires the consideration of the ecological effects in receiving water of effluent discharges from implemented control technologies and management methods.

To set an effluent standard to offer reasonable protection to aquatic environments but no stricter than necessary, requires prediction with reasonable accuracy of dispersion, transformation, accumulation and effects and economic damages of pollutants from the time they enter the environment to the time they are diluted to harmless levels (if that happens).

Over the past few years, many accomplishments have been achieved in the ecological effects program. Some of the most noteworthy are summarized below.

Significant contributions were made to the establishment of EPA's Water Quality Criteria and to the Effluent Guidelines Program. Bioassay procedures were developed which have been useful in a variety of ways, particularly in the Ocean Disposal Permit Program.

The development and application of eutrophic and phytoplankton production models of Lakes Ontario, Erie, and Huron have been completed, as has the evaluation of accumulation of polychlorinated biphenyls (PCBs) and other organic contaminants in Great Lakes fish. The National Eutrophication Survey has terminated and a large portion of the results have ben analyzed and published. This extensive data base on the state of health of the nation's freshwater lakes will assist states and municipalities in their water quality management activities.

A lake polluted by nutrients from municipal wastewater has been restored to near-pristine quality following years and research and testing by EPA scientists. Although it is extremely difficult to determine the dollar value of the achievement of Shagawa Lake, Minnesota, it is certain that the economic benefits have been enormous in terms of rapid recovery time and the improvement of an important recreation area by removal of phosphrous.

Research on gas-bubble disease, or supersaturation of water resulting in a condition similar to the "bends" in humans, has resulted in a large saving to the taxpayer and the protection of the commercially important Salmon resource in the Pacific Northwest. Effects research established a criterion of maximum permissable supersaturation of 105% in the Snake and Columbia Rivers. Had this research not been conducted, the Corps of Engineers likely would have made exorbitant expenditures to redesign and restructure dams in an attempt to solve the problem without adequate scientific data.

Effects research has been essential to EPA's pesticide registration program and basic to several Agency actions concerning the banning of pesticides such as DDT, aldrin, and dieldrin. A program was initiated to investigate the health and ecological implications of the use of substitute pesticide chemicals. Also initiated was a program to develop alternate (non-chemical) methods of pest control.

The Ecological Processes and Effects Subprogram is structured into four categories. They are Air and Water Quality, Pesticides and Toxic Substances. In each category, criteria is developed based on ecological effects to living organisms and ecosystems. The criteria is set so as to mitigate any noticable detrimental effect on desirable ecosystems.

Ecological criteria development includes laboratory studies, such as bioassays, to establish tolerable pollutant levels. It also includes determination of single species effects or higher level effects such as those obtained from well-defined microcosm simulation. General work performed under criteria development is in direct response to legislative mandates to define numerical standards to ambient level of pollutants. Since establishment of a pollutant ambient level implies control practices, this activity has economic implications.

Systems characterization and impact assessment include field studies; theoretical or mathematical simulations; development of methodologies to assess socioeconomic impacts of pollutants, including assessment of resource utilization; and characterization of laboratory model ecosystems or microcosms for potential use in criteria development. As such, the ecological criteria portion of the program provides a response to requests for numerical criteria on the effects of specific pollutants on sensitive living components in air, water and terrestrial systems. Systems characterization and impact assessment require longer range research effort to make numerical criteria more meaningful for whole systems.

In the future, effort will be placed on systems studies designed to yield information on pollutant effects on entire systems. In the past, ORD criteria for effects were based on studies of selected species. Current scientific opinion and recent judicial proceedings indicate a need to evaluate the impact of pollutants on entire systems as well as on individual species. Unfortunately, satisfactory methods for such systems evaluation are still inadequate.

The following sections describe major aspects of the five-year plan describing anticipated major outputs and research approaches.

Air Quality--

Air pollutant effects research on the structure and functions of ecosystems and especially on their economically useful components, has as major goals the protection of terrestrial ecosystems and thus human welfare. Projects utilizing laboratory, microcosm, greenhouse and field studies provide data which is interpreted using mathematical and/or theoretical simulations to support establishment and continued evaluation of air pollutant criteria. The information obtained is also relevant to developing guidelines to assess the environmental impact of municipal, industrial, agricultural, and energy resource development.

The scientific basis for developing and strengthening air quality control strategies and for evaluating air quality standards for major criteria air pollutants will be continued on agricultural and forest plants. Both acute and chronic effects on all stages of plant growth and reproduction will be studied, with emphasis on ozone, nitrogen dioxide and sulfur trioxide.

The present program to establish the scientific basis for air quality criteria for non-criteria pollutants (e.g., heavy metals, halogen compounds etc.) will continue on agronomic, horticultural and forest ecosystems. Acute crises pollution problems frequently involve the non-criteria pollutants, but chronic effects may present the worst hazard. Both aspects are being investigated.

Measurement of acute and chronic effects of airborne photochemical oxidants upon selected forest and agricultural ecosystems will be continued. In this work, for example, questions will be addressed such as whether conifer forests may exhibit widespread damage from these pollutants. Research results will be incorporated into descriptive and predictive models.

Determination of acute and chronic ecological effects of major air pollutants, singly and in combination, upon agricultural ecosystems will permit an assessment of the economic and social costs which may be determined in conjunction with the field and laboratory program. Human food and animal forage crop ecosystems damaged by air pollutants constitute direct threats to human welfare.

Establishment of coal-fired power plants in remote parts of the West emphasize the need for ecological effects research, especially on livestock rangeland. Thus, determination of acute and chronic ecological effects of major air pollutants singly and in combination upon forest and grassland ecosystems remains an important effort.

For future food production it is imperative to determine ecological effects of air pollutants within soil systems as a result of their transport, transformation, accumulation and dispersal through biological, physical and chemical means. Soils represent the nutrient bank for all terrestrial ecosystems. As damage to soils may be irreversible, this research seeks to quantify and assess the potential harm from such sources as airborne acid aerosols and metals.

Water Quality--

The goal of the ecological effects program in aquatic ecosystems is to provide the Agency the basis for the development of water quality criteria, for fresh and marine waters.

The ecological effects research program conducts research on the effects of specific pollutants and pollutant combinations on representative or key sensitive organisms in aquatic ecosystems and on critical ecosystem parameters and processes. Also under investigation are the physical, chemical, and biochemical transformations of pollutants which result from their introduction into, or passage through, aquatic ecosystems. Additional research includes the characterization of natural and stressed aquatic ecosystems; environmental requirements and limits for aquatic organisms; development of mathematical ecosystem simulations and laboratory models which aid in the prediction of pollutant stress effects on aquatic biota and ecosystems; and methods to measure the relative health of aquatic ecosystems. Inherent in the above is the consideration of intermedia transport and effects, wherever applicable.

A major research objective in this program is to determine the fate and ecological effects of oil and derived hydrocarbons in marine and freshwater ecosystems. The laboratories are conducting research on the nature, loading and long-term effects of oil in arctic and subarctic ecosystems. Studies are being conducted on the toxicity of petrochemicals and energy related organic solvents derived from off-shore petroleum extraction and transportation; and on the distribution and degradation rates of carcinogenic compounds derived from oil.

Studies are underway to determine the fate, transport, and effects of non-pesticide organic and inorganic pollutants, singly and in combination, on aquatic species, ecosystems, and on community structures and populations: Research to meet this objective includes studies on the influence of organic solvents on the toxicity of selected organophosphates and chlorinated hydrocarbons to fish; the effects of pollution stress on the susceptibility of certain fish species to diseases; the toxic effects of inorganic pollutants originating from non-point sources; and toxic effects of asbestiform fibers and inorganic pollutants.

The objective of several studies ranging from the organism to the ecosystem level is the determination of the ecological effects of disinfected wastes disposed in aquatic environments. Studies are designed to determine the toxicity of industrial and municipal waste treated with disinfectants and the dynamics-of-dispersion and bioaccumulation of chlorine and halogenated compounds formed when chlorine is introduced into the marine environment. Because of its potential as an alternative to chlorine for disinfection, the effects of ozone upon selected marine and estuarine species are being studied under varying environmental conditions such as temperature and salinity.

A major thrust of the program involves studies of the Great Lakes. Objectives include the characterization of pollution problems of the Great Lakes, determination of the dynamic processes affecting large lakes, and development of management-oriented models for describing the fate and effects of pollutants in the Great Lakes. Research to meet these objectives includes studies on oxygen consumption; relationships between nutrient control and eutrophication, plankton, benthos and fish populations; fates of hazardous substances, and atmospheric input of pollutants.

EPA scientists are working to determine the estimated "safe concentrations" for freshwater aquatic life of complex industrial effluents receiving best practicable treatment. Procedures are being developed for sampling and conducting bioassays of complex wastes in marine and freshwater. Research is being conducted on the integration of the exposure history of aquatic organisms to complex wastes which vary with time in concentration and components. Refinement of the use of the cough response of fishes as a "toxic unit" of chronic exposure, is being accomplished. This information can be used in setting and adjusting ambient water quality standards.

Determinations are being made of the effects of freshwater ecosystems on the transformation of pollutants to other toxic or non-toxic forms and bioaccumulation of waterborne materials, including rates of accumulation, ultimate organism or tissue sites, and persistence of the compounds produced. This research involves studies of bioaccumulation of pollutants by plankton, benthos and fish. The formation of associations between organic pollutants and suspended and dissolved organic materials; the toxicity of persistence pollutants as related to sorption-desorption phenomena.

An objective of the water program is to determine the fate, transport, and effects of municipal and industrial wastes, disposed of in the ocean and of dredged materials in marine and estuarine ecosystems. This research involves the study of the mobilization of pollutants in dredging and discharging modes; the prediction of physical, chemical and biological influences on pollutant fates; the accumulation of viruses in sediments and in organisms resulting from the ocean disposal of treated muncipal wastes and the physicochemical factors affecting algal assay procedure results in estuaries. The research will be used in the development of receiving water criteria for ocean outfalls and ocean disposal and the development of an environmental evaluation decision scheme for evaluating ocean disposal permit applications.

Simulated ecosystems are being developed to assess or estimate ecological alterations, assess the dynamics of physical, chemical and biological processes, and to test biostatistical methods to quantitatively sample ecosystem components. Predictive models which describe pollutant distribution and interactions are being developed and validated. Transport models are being developed which will predict the magnitude and distribution of settled and suspended materials resulting from dredge material disposal. Single and multispecies static and flow-thru bioassays are being developed and applied to problems such as ocean disposal, thermal discharges and the discharge or disposal of metals, oil, mixed wastes and dredge materials.

Another objective of the program is the development and evaluation of the ecological significance of measures of aquatic community structure as indicators of the "health" of marine and freshwater ecosystems. The research involves the comparative study of the effects on community structure of stresses applied to different assemblages in different biogeographical provinces. This work will help to identify those indices which are useful for quantitative impact assessment or measures of possible effect.

An objective of the water program is to determine the ecological impacts of variations in environmental parameters and the responses of aquatic organisms to stress. This research involves studies of thermal shock on fish and invertebrate larvae; the dynamics of fouling communities under low-level, long-term thermal stress and simultaneous or intermittent stresses resulting from other sources; and effects of oxygen concentration on the growth and survival of embryos and larvae.

Nutrient loading, nutrient sources, rate-limiting nutrients and trophic conditions are being assessed for selected lakes. Assessment is being made of the contribution of nutrients and other pollutants from nonpoint sources and their impact on surface water ecology. Determinations are underway of nutrient recycling from sediments and the relative importance of nutrient cycling by freshwater biological communities compared to physical-chemical cycling from sediments. This research involves the use of laboratory microcosms as well as field techniques in lakes other than the Great Lakes. Included in the analyses are data from 800 U.S. lakes collected for the National Eutrophication Survey and data on the long-term responses of a lake to phosphorus reduction.

Studies are being conducted to describe and evaluate the dynamics of aquatic ecosystems under pollution stress. A variety of lake restoration techniques are being evaluated to provide a better understanding of the overall environmental, social and economic costs and benefits associated with the restoration of water quality in eutrophic lakes.

Pesticides--

A major objective of the ecological effects research program is to provide information to assist the Agency in the registration/reregistration of pest control agents and in the formulation of policies involving the registration process. The efforts that support this objective are research on ecological effects of pesticides and substitute pesticide chemicals. Another significant objective is to develop pest control strategies that utilize all available methods in a way that is least destructive to the environment. This part of the research program is known as integrated pest management.

The ecological effects portion of the research program is oriented toward determining the effects of pesticides in aquatic ecosystems. That part of the research program designated the Substitute Chemical Program develops, validates, and utilizes suitable methods and techniques to assess the ecological effects of candidate substitute pesticide chemicals on terrestrial and aquatic ecosystems. Pesticide transport, fate and other pertinent ecological properties are also investigated in the Substitute Chemical Program. The Integrated Pest Management Program provides the necessary basis for development of strategies and tactics of insect pest control in major crop ecosystems which will possibly permit marked reduction of dependence on pesticide chemicals as a regular pest management practice. A similar but smaller effort is devoted to the development of a scientific basis for control strategies for urban pests. A discussion of the integrated pest management program can be found in the section on Renewable Resources Industries.

A major thrust of the ecological pesticide research program is to determine the effects of selected pesticides on marine, estuarine and freshwater organisms and ecosystems. The acute and chronic effects of varying concentrations of pesticides on aquatic organisms are studied for representative species exposed during various life stages. The effects of varying concentrations of pesticides on the development of ecosystems or communities are studied to determine relationships between pesticide concentration and species composition, species diversity, and community interactions.

One segment of this ecological part of the program is oriented toward determining the effects of anti-fouling biocides on estuarine organisms and ecosystems. The effects of varying concentrations of anti-fouling biocides upon selected estuarine organisms are being studied to determine acute toxicity relationships between the biocides and individuals life stages and to determine chronic effects of sublethal concentrations on sensitive life stages. The effects of these biocides on ecosystems are being studied to determine community composition, rate of development, population dynamics, and species diversity.

Another part of the program examines pesticide-microbial interactions in estuarine environments. The effects of selected pesticides on commonly occuring microorganisms are being studied to determine microbial degradation of pesticides, including rates and products produced and to determine toxicity of pesticides to pure cultures.

Research efforts are being turned toward the interactions of biological control agents with chemicals introduced to the environment in various ways. Further, with regard to chemicals, the occurrence and ecological significance of carcinogens, teratogens and mutagens in the marine and estuarine environments is being investigated. An example of this type of work is that on the effects of infectious pathogen agents upon estuarine organisms in the presence of environmentally occuring chemicals like PCB's. The relationship between suspected carcinogens, teratogens, mutagens and chemical combinations is being studied for selected species; results will be compared with those obtained for mammals.

Among the important investigations of substitute chemicals are those on the routes, degradation rates and effects in terrestrial and aquatic ecosystems. Suitable methods and techniques for assessing deleterious and beneficial ecological effects of substitute pesticide chemicals when they may be used or transported in the terrestrial, estuarine, marine, and freshwater ecosystems will be developed validated and utilized. Transport of pesticides and their degradation products within the environment, pesticides bio-accumulation, and other ecological properties will be evaluated according to designated use or environmental mobility.

Toxic Substances--

As in the health program, toxic substances research discussed in this section is part of a program initiated in prior years. It has not yet been made a specific part of the overall implementation of the Toxic Substances Control Act of 1976 (TSCA), but is relevant to it. As EPA moves to implement TSCA in the current and ensuing years, this program will be directed specifically to supporting needs in that area. The objectives of the research are to determine the ecological effects of toxic substances and to provide a scientific basis for criteria development where possible and necessary. Multimedia microcosm techniques, as tools to predict pollution transport and distribution, are being tested and evaluated to determine the impact of size, ecological structure, and abiotic components on the microcosm responses. The stability and reproducibility of microcosms are being determined in relation to the above factors. The degree of reliability of various types of microcosms (both aquatic and terrestrial) to predict pollutant transport and distribution are being attained from these studies and improved microcosm utilization techniques are being developed.

In order to establish the suitability of the microcosms and model ecosystems for criteria development and as screening tools for toxic contaminants, existing units are being characterized as to replicability and effects of size and structure. Work is being done to identify the applicability of these model systems to real-world ecosystems.

EPA scientists are developing and characterizating new model ecosystems and microcosms capable of simulating a range of key ecosystem-level processes and parameters, and suitable for evaluating major categories of ecological stressing factors. Characterized model ecosystems and microcosms will be used to screen toxic contaminants to provide estimates of probable ecosystem-level effects on specific environmental-stressing factors.

Potential Subprogram Growth Areas--

In the majority of activities described under the Ecological Processes and Effects Subprogram, a resource allocation as summarized in Section I as the growth budget option, would permit more timely achievement of the ecological research objectives. Specific output delays which could be averted, new initiatives in research and reinstated research activities are discussed below.

In the air ecology category, work dealing with development of population-dynamics models for air pollutant effects on terrestrial plant and animal communities would be restored. Research on development of pollutant transport mathematical.models describing transport pathways of airborne hazardous substances (e.g. particulates, heavy metals, etc.) to selected terrestrial plants and animals would be restored. The very modest effort on ecological effects of acid precipitation upon agricultural and non-agricultural ecosystems and their components; and upon soils, soil biota, and soil fertility would be reestablished. Long-term effects on soils and short-term effects on plant growth, yield and reproduction would be emphasized. An additional effort could be undertaken to determine the near and long-term ecological effects of acid precipitation. The long-term effects of acid rain on soil litter decomposition will determine the extent of damage to this key step in plant nutrient recycling. Short-term effects will deal with direct damage of acid precipitation to agronomic and/or horticultural crops. A portion of the resources would also be used to support the USDA acid rain monitoring network now being proposed.

In the water ecology category, extramural projects on the atmospheric input of heavy metals into the Great Lakes; thermal pollution; and effects of nutrient loading on algae growth would initiated. No delay of scheduled research would occur involving the dispersion and fate of hazardous materials in the Great Lakes; bioassays designed to determine permissable levels of petroleum hydrocarbons in the marine environment; completion of bioassays on permissable levels of heavy metals in marine ecosystems; bioassays on the ecological impacts of disinfectants; studies on the characterization of freshwater ecological processes; and the development of bioassays to study the effects of complex wastes on estuarine and marine organisms and ecosystems.

In the pesticide category, continued support of all active extramural projects not scheduled for completion in FY'77 would be possible. This is significant since it would allow timely output of information on the effects of specified pesticides. Those areas of research most affected would be toxicity testing, evaluation of substitute chemicals in terrestrial model ecosystems and determination of the effects of selected pesticides on the marine environment.

In the toxic substances category it will be possible to achieve earlier completion of an evaluation of terrestrial and aquatic microcosms. This evaluation will examine the ability of the microcosm to assess potential environmental transport and distribution of toxic pollutants. With the completion of this developmental phase, screening of selected substances in model ecosystems or microcosms for fate and effects can begin.

Transport and Fate of Pollutants Subprogram

Development of effective pollution control strategies requires linking pollutant impacts to sources. The Transport and Fate Subprogram is primarily responsible for development of empirical and analytical techniques that relate air and water pollution source emissions and discharges to ambient exposures. To achieve this objective requires research and model development in atmospheric, soil and aquatic ecosystem processes and effects for determination of pollutant sources, interactions, transport, transformation and sinks; effects of air pollutants on visibility, rainfall, and climate; and impacts of water pollutants on water quality.

Following is a description of transport and fate research and an identification of major outputs over the next five years.

Air Quality--

The Clean Air Act of 1970 introduced an era of stringent standards and deadlines for achieving air quality goals. However, some ramifications of achieving clean air have only recently come sharply into focus. The direct costs of achieving clean air by control of stationary and mobile sources are better known than the indirect impacts on land use and energy supplies. Additionally, the goal of clean air must compete with other national needs. Application of "hardware" controls alone may not be sufficient nor the optimum solution to air quality improvement. Rather, the optimum control choice may depend upon an understanding of the processes of pollutant formation, transport and fate, the interactions of pollutants and their subsequent impact on ambient air quality.

Knowledge of many atmospheric processes governing transport and transformation of pollutants in the atmosphere has progressed. However, new information has revealed significant information gaps that may hinder progress in effectively managing atmospheric quality. The gaps most likely to receive attention in the near-term include the transport and alteration of sulfates under both regional and subcontinental conditions, and analysis of oxidants in local and regional areas. Emerging problems, such as carcinogens and other hazardous substances, are also likely to receive more attention.

A major objective in the air research category is to achieve a better understanding of transport and fate processes through the design and testing of air quality simulation models. Simulation models are developed, evaluated and validated to provide qualitative and quantitative methods for predicting and describing air quality from a variety of emissions sources. Included in these activities are model development for important pollutant categories and configurations (e.g., highway, point sources, area sources, etc,), model evaluation, model testing protocols and guidelines for physical model use.

In addition, the following specific catgories of research are addressed within the Air Quality research area: determine and characterize the sources and sinks, mechanisms and kinetics of formation and removal, and chemical/physical interactions of airborne gaseous and particulate matter; qualitatively and quantitatively estimate or describe air quality associated with a variety of anticipated air pollution control abatement strategies and develop the necessary analytical techniques to characterize and measure air pollutants from stationary and mobile sources and in the ambient air. The major air pollutants under study are the criteria pollutants and important non-criteria pollutants including sulfates and other sulfur-containing compounds, nitrates, halocarbons, polynuclear aromatics and other carcinogens, and fine particulates. Research results are needed by the Agency to establish effective control measures to meet ambient air quality standards and to justify and defend the establishment of emission limitations on selected stationary and mobile sources. The measurement and evaluation of the atmospheric effects of pollutants, in support of secondary air quality standards, include determinations on the effects of pollutants on visibility reduction.

Using chemical and physical concepts, analytical tools and measurement methods developed over preceding years, air quality research will continue to investigate ambient air pollutant transformation, movement and removal, but with increasing emphasis in the following areas.

- On particulate pollutants as contrasted with gaseous pollutants.
- Analysis of data, accumulated from long-term surveillance projects, as opposed to data gathering.
- Study of regional air pollution problems rather than solely on urban-scale problems is anticipated to continue over the next five years.
- On non-regulated pollutants such as vinyl chloride, specific organics, carcinogens, nitrates and sulfates and other sulfur-bearing compounds, and less on the conventional criteria pollutants.

Key outputs over the next five years are presented below.

Sulfate Transport and Transformations in the Environment (STATE)--The STATE is designed to acquire the data base necessary for the development of control strategies for the reduction of sulfur and nitrogen transformation products in the atmosphere. To obtain such information will require aerometric and meteorological measurements on an areawide scale of 100 - 100 km combined with vertical characterization (within the troposphere) to describe and predict pollutant concentrations at ground level. Specific milestones will include:

- Conduct winter field studies (include snow cover; steady precipitation).

- Conduct summer field studies (include stagnation; shower precipitation).
- Preliminary report on 1978 Winter Field Studies.

Upon completion of STATE, outputs will be provided that describe:

- Extent to which oxides of sulfur and nitrogen rates of conversion and deposition are influenced by sunlight, ammonia, catalysts, humidity, terrain and vegetation, and meteorology.
- Influence of air mass on sulfate and nitrate composition.
- Contribution of natural sources of hydrogen sulfide to ambient air concentrations of sulfates.
- Behavior of sufur dioxide, sulfates, nitrogen oxides, and nitrates coming from large point sources, as opposed to area sources.
- Final report on the STATE program.

Air Pollutant Characterization--

- Final report on the distribution of halogenated compounds in the troposphere.
- Report on natural sources of oxidant precursors.
- Report on non-regulated pollutants in the New York-New Jersey area.

Air Quality Models--

- Application of three-dimensional finite difference line-source model for assessing concentrations on and near highways.
- Development of a regional scale air quality simulation model for ozone.
- Complete evaluation of urban scale models for oxidants and sulfates from RAPS data.
- Development of a nitrogen dioxide precursor relation from chamber simulations.

Physics and Chemistry of Gaseous and Particulate Pollutants--

- Develop a lumped parameter kinetic model for aromatic hydrocarbons to fill out oxidant photochemical lumped parameter kinetic systems.

Atmospheric Effects and Meteorology--

- Report on the determination of the anthropogenic and non-anthropogenic pollution emissions to visibility deductions in the U.S.

Water Quality--

The establishment of meaningful surface and ground water quality goals and standards, and the implementation of a cost-effective program for their achievement and maintenance, require a capability to relate pollution discharges to ambient water quality conditions and vice versa. Specifically, this capability is essential in order to establish ambient water quality standards and effluent limitation for compounds that are toxic or that are transformed into toxic substances after release to the environment; predict the hazard (and its duration) that would result from the release to surface or ground waters of substances that are toxic or are capable of transformation into toxic substances; translate water quality standards and goals into point (and nonpoint) source control requirements, as necessary for the issuance of permits along water quality limited stream segments; and optimize point and nonpoint pollution control/management requirements within a basin with respect to dollar and energy expenditures.

The current state of the art in this area is sufficient to permit prediction of water quality impacts resulting from point source discharges of the more common pollutants (e.g., BOD, coliform, excess heat). The accuracy, precision, and limitations of these existing predictive models have not been fully verified and documented, however, and it is not generally obvious which of the existing techniques is most applicable in a given situation or what the degree of error might be in any given application. The capability to predict water quality impacts from point-source discharges of nonconventional toxic pollutants is essentially nonexistent. There is also essentially no capability to relate nonpoint discharges of pollution to resultant water quality or to predict water quality improvement that would result from any given level of nonpoint-source control. Also lacking is essential information on four of the key environmental processes (microbial degradation, oxidation, volatilization, and sorption) that dictate the movement, primary pathways, transformations, persistence, and ultimate fate of trace organic and inorganic substances in surface and ground water systems. This information is necessary in order to develop screening techniques for rapidly assessing the nature, extent, and duration of the hazard that would result from the deposition of a given potentially toxic substance into an aquatic system or upon the land. This information is also required to expand existing predictive models to address the impacts of point and nonpoint discharges of pesticides and other toxic materials on surface and ground water quality.

The major objectives of current research on the transport and fate of water pollutants are to provide the methodologies and associated data bases required to: 1) predict the transport, transformation, persistence, and fate of trace organic and inorganic pollutants upon entering a fresh surface or ground water system; 2) predict water quality impacts resulting from the discharge of point and nonpoint source pollution into fresh surface waters; and 3) evaluate the relative cost-effectiveness of alternative basinwide point and nonpoint source pollution control strategies.

In view of the above objectives, the following outputs are planned for the five year period FY 77 - FY 81.

- Reports characterizing sensitized photolysis, chemical oxidation, volatilization, and sorption processes with respect to their roles in the transport, transformations, and fate of trace organic pollutants (supports Toxics and NPS Modules).
- Report on impact of multi-pollutant interaction of fate processes (supports Toxics and NPS Modules)
- Report on impact of environmental factors on release and degradation of pesticides from sediments in sediment-water systems (supports NPS and Toxics Modules).
- Report on evaluation of expanded and refined pesticide evaluative model (for predicting the transport and fate of pesticides in fresh water systems) (supports Toxics and NPS Modules).
- Report on expanded inorganics (mercury) evaluation model, calibrated for cadmium (supports Toxics and NPS Modules).
- Report and users manual on evaluative model for major nutrients (P,N, & C) (supports NPS Module).
- Report and users manual on expanded nutrient evaluation model (to include impact on metals and other toxic substances on nutrient cycling) (supports NPS Module).
- Couple inorganic and organic evaluative models with those for other media so pollutants can be evaluated for multimedia behavior (supports Toxic Module).
- Report on "natural" loading rates for sediments and nutrients in natural streams (supports NPS Module).
- User manual for a user-interactive computer program (Executive Routine) for conducting basinwide assesments of point and nonpoint pollution problems and the effectiveness of proposed management alternatives in the alleviation of these problems (supports NPS Module).
- Report documenting selected methodology for quick analysis of specific pesticide and other toxic pollutant problems on an areawide or basinwide scale (supports NPS Module).
- Report on Areawide (sub-basin or watershed scale) point and non-point source loading and water quality impact analysis model (support NPS Module).

- User manual for a hydrologic unit, (sub-watershed scale) point and nonpoint source loading and water quality impact analysis model (supports NPS Module).

Potential Subprogram Growth Areas--

Transport and Fate of Pollutants Subprogram activities can productively result in research outputs with the increased support afforded by the proposed growth budget option summarized in Section I.

Specific project outputs in the Air Quality category that would be additional to the planned efforts are listed and grouped into the five major research areas of the Air Quality category as follows:

STATE--

- Impact of photochemical processes as they affect the sulfur dioxide and nitrogen oxides from different sources.
- Mechanism and rate of formation of sulfate and nitrate aerosols and characteristics in different regimes.
- Decay rate of sufur dioxide from area sources as opposed to point sources, and in the combined urban plume.
- Behavior of sulfur and nitrogen oxides from a power plant when emitted above the inversion layer, as opposed to being emitted below the layer.
- Importance of the nitrogen oxides from power plants, if any, to the formation of ozone downwind of cities.
- Effectiveness of natural precipitation processes to remove nitrogen and sulfur oxides from the atmosphere.
- Role of sulfates and nitrates in contributing to acid rain problems.
- Development of regional/sub-continental models that relate emission sources to ambient air concentrations for nitrates and sulfates.

Air Pollutant Characterization--

- Chemical characterization of acid sulfates at selected U.S. sites.
- Reports on non-regulated pollutants in Birmingham.
- Report on air pollutant characterization in an agricultural area in Region VII.
- Reports on ambient air concentration levels of carcinogenic substances at selected urban and non-urban sites in the U.S.
- Reports on ambient air concentrations of toxic substances.

Air Quality Models--

- Evaluate the validated models for sulfur oxide emissions from power plants in complex terrain.
- Report on the use of advanced statistical concepts in the development of Air Quality Simulation Models.
- Development of oxidant-precursor models for multiple-day irradiation from chamber simulations incorporating hydrocarbons and nitrogen oxides as simultaneous precursor variables.
- Report on recommendations for control of fine particulates.

Physics and Chemistry of Gaseous and Particulate Pollutants--

- Smog chamber study of sulfate formation under high relative humidity.
- Report on potentially toxic intermediate oxygenates in photochemical smog formation.
- Report on aerosol analysis for organics, nitrogen and sufur oxides, amonia, and hydrochloric and nitric acids.
- Determine composition of toxic secondary products (chemical reaction) compared to primary organic vapors and particles in several urban and non-urban atmospheres.
- Determine formation and destruction mechanisms for toxic organic vapors and organic particles in urban and industrial plumes.
- Study natural atmospheric removal processes for sulfur oxides from plumes.

Atmospheric Effects and Meteorology--

- Report on the effects of air pollutants in the urban-rural radiation balance.
- Report on plume rise climatology for the U. S.
- Progress report on the role of percipitation washout and rainout on sulfates and nitrates.
- Assessment of air pollution modification of regional weather and climate.

In the water quality category, many scheduled outputs, within the time frame needed to implement TSCA and to complete the first phase of areawide planning by 208 agencies, could be obtained under the growth budget option. Specifically the accelerated amounts and specific projects are as follows:

- Report and users manual on expanded nutrient evaluative model (to include impact of metals and other toxic substances on nutrient cycling) - by one year.
- Couple media-specific evaluative models to produce multi-media evaluative models for assessing transport and fate of trace organic and inorganic pollutants -- by three years.
- User manual for Executive Routine for conducting basinwide assessments of point and nonpoint pollution problems and the effectiveness of proposed management alternatives -- by one year.
- Report on areawide (sub-basin scale) water quality analysis model -- by three years.
- Expanded basin-scale analysis models for assessing pesticide and other toxic pollutant problems on a basinwide basis -- by two years.

- Initiation in FY 1978 (& Completion in FY 1985) of the verification and documentation of the validity and accuracy of the linked NPS loading and water quality impact analysis models identified above and up to three other models that would be considered desirable for use in making point source load allocations.
- Initiation in FY 1981 (& Completion in FY 1987) of the development of methodologies for optimizing alternative combinations of point and nonpoint source pollution control strategies within a watershed or basin.
- Support of implementation of TSCA by the development of protocols for rapidly assessing the transport and exposure pathways and fate of toxic substances. The very rudimentary first generation protocols would be developed by 7/1/77, utilizing existing state of the art techniques. Subsequent efforts would be devoted to reducing by several fold the cost and time requirements for employing the protocols and increasing their reliability.

Criteria Development and Socioeconomic Studies

The health and ecological effects research program has the responsibility for preparing criteria-type documents which assess the available scientific and technical information applicable to possible regulatory actions on specific pollutants and for socioeconomic research related to health and ecological effects. The criteria development program has the responsibility for preparing the Criteria Documents required under Section 108 of the Clean Air Act as well as Scientific and Technical Assessment Reports (STARs) on other pollutants. The socioeconomic research area seeks primarily to develop methodology for better estimating the economic benefits of pollution control. It draws on the health and ecological effects data generated by the other parts of the program as well as by EPA sponsored research.

Those criteria-type documents now under preparation or scheduled are shown in the timeline projections. Particular pollutants for which criteria-type documents will be prepared in the latter part of the five-year period will depend on future EPA intentions as to which pollutants to regulate. In general, the documents will be prepared in most cases in a three-stage development process in which a contractor will carry out the basic literature search, a group of experts on the particular pollutant will use this to prepare an overview assessment of the pollutant, and then ORD scientists will summarize and define the impact of the documents on EPA. Except in the case of Section 108 Criteria Documents, each STAR will be as multimedia and multidisciplinary as is reasonable considering expected users. There is expected to be a continuing and growing need for such documents over the next five years, particularly for the increasing numbers and kinds of toxic pollutants with which EPA is concerned.

The socioeconomic research area emphasizes research on the benefits of health and welfare protection and pollution abatement. Where possible, reports of suitable quality and length for publication as books are sought as outputs. Several major reports are expected through FY 78. The topics proposed for later years will be selected mainly from other areas of benefit research and a limited selection of topics from the following areas: economic epidemiology, future pollutant problems, conservation issues, waste reduction, and methods and model development.

The economic epidemiology area considers socioeconomic and demographic factors associated with environmental health. These data will serve to implement the medical epidemiology and provide data for benefits studies. The future pollutant problem area is an interdisciplinary one that attempts to "get ahead of the problem" and identify future pollution problems early enough to devise control strategies that protect at much lower cost than required when the problem becomes serious. The conservation issues area will define the problem of evaluating natural environments and outline various approaches for coping with conflicts of interest between conservation of nature's unique natural features and economic development. The waste reduction area will explore resource depletion problems and environmental and economic benefits of reducing the amount of wastes; methods of encouraging materials conservation and consequences of alternative management methods. In the methods and model development area, tools appropriate for use in environmental analysis will be developed, verified and prepared for socioeconomic assessments.

The major objectives of the benefit research program are to develop the methodology necessary to allow credible assessment of pollution control benefits for each media as well as for selected individual pollutant control actions. It is anticipated that there will be a continuing and growing need for socioeconomic research over the next five years as the number of pollutants of concern increases. As this happens, EPA will find it necessary to exercise ever-increasing selectivity as to the level and extent of control exercised so as to avoid unnecessarily excessive regulation of consumers and industry. Improved benefit data can contribute greatly to this goal.

Varying resource levels will have approximately proportional impact on the output of the criteria and socioeconomic programs, by varying the number of assessments under each program.

TIMELINES FOR CRITERIA-TYPE DOCUMENTS

Pollutant	FY-77	FY-78	FY-79	FY-80
Ammonia	○△		▼	
Arsenic	○△ ▼			
Asbestos	○△			
Benzidine		○△		
Beryllium		○△		
Cadmium	○△			
Carbon Monoxide	○△		▼	
Chlorine & Hydrochloric Acid	▼			
Chromium		△		
Copper	○△	▼		
Cyanides	○	△		
Endrin	△			
Fluorides	○	△		
Halomethanes (non-fluorinated)	○△			
Hexachlorocyclopentadiene, Kepone, Mirex	○	△		
Hydrogen Sulfide	○△		▼	
Iron	○△			▼
Lead (airborne)	▼			
Lead (multi-media)	△			
Mercury		△		
Methylparathion	△			
Nickel	▼			
Nitrogen oxides (air)	○△		▼	
Nitrates	○△			
Nitrosamines	▼			
Noble metals	○△		▼	
Particulates	○△			▼
Phenols	○	△		
Photochemical oxidants & hydrocarbons		▼		
Selenium		▼		
Sulfur oxides, including sulfates			○△	▼
Toxaphene	○	△		
Vanadium	▼			
Vapor-phase organic matter			▼	
Zinc	○△	▼		

○ = Literature review completed.
△ = Assessment completed.
▼ = In-house review or report completed.

PUBLIC SECTOR ACTIVITIES PROGRAM

The major goals of the Public Sector Research Program are:

- To develop waste water management technology to meet the objective of P.L. 92-500 as it pertains to public sector activities.
- To develop solid waste and resource recovery technology in support of the objectives of P.L. 94-580.
- To provide the R&D support to implement the the safe drinking water provisions of P.L. 92-523.
- To develop alternative technologies for ocean disposal in support of P.L. 92-532.
- To develop improved methods for planning and implementing regional environmental protection programs.

Of the environmental problem areas of concern to EPA programs, several can be grouped because of their significance in community environmental management. Three major research subprograms are so identified and are:

- Waste Management
- Water Supply
- Environmental Management

The Waste Management Subprogram focuses on prevention, treatment control, and management of pollution produced by community, residential or other nonindustrial activities. This research covers municipal and domestic wastewater collection/transport and treatment systems, urban surface runoff, and municipal solid wastes systems.

The solid waste systems research effort includes documentation of effects to justify regulatory efforts for hazardous wastes disposal, control technology development for their treatment and disposal, determinations of their migration through soils, evaluations of environmental effects of sanitary landfills used for their disposal and development of resource recovery systems for wastes for energy and material conservation and recovery.

A major effort is underway to assure the Nation a dependable and safe supply of drinking water. This includes work on health effects that result directly or indirectly from contaminants in drinking water. Additionally, the Water Supply Subprogram provides for development of analytical methods to assess drinking water quality and to develop processes to control undesirable contaminants in water supplies that currently applied technology does not remove. Water supply research includes four major efforts: identification and measurements, health effects, treatment technology and systems management, and groundwater management. The major objective of water supply health effects research is to develop scientific criteria for setting drinking water quality standards. Specifically, this research will provide the scientific information to establish standards for organic, inorganic and microbiological contaminants in drinking water. The primary objective of water supply control technology R&D is to develop cost-effective control technology to achieve standards. This involves both the adaptation of large-scale technology to small water supply streams and development of new or special technologies.

The objective of the Environmental Management Subprogram is to provide regional, state and areawide environmental planners and managers with methods to determine feasible alternative solutions to comprehensive environmental problems and to provide techniques for selecting least-cost solutions. The research focuses on development of improved multimedia planning techniques, improved methods for collection, analysis and application of environmental quality and economic information,methods for the evaluation of alternative institutional arrangements, and the development of comprehensive systems evaluations and decision methodologies.

Description of the three subprograms and their major planned five year outputs follows.

Waste Management Subprogram

The domestic, commercial, recreational and other nonindustrial activities of the Nation's communities are major sources of pollution and degradation of environmental quality. These many and diverse communities vary from isolated rural settlements and recreational areas to sprawling suburban developments and large, concentrated urban areas. Community activities, normally under management of state and local governments produce pollutants that are discharged into the Nation's surface and groundwater from sewered wastewaters, runoff from rain and melted snow from the land's surface, percolation of pollutants from home septic systems and public or private landfills. Also, there are emissions of pollutants to air from public sector activities sources, and other impacts resulting from solid and hazardous wastes.

The EPA has a number of ways to approach public sector problems. The most conspicuous and direct is the Federal Construction Grants Program with its National Pollutant Discharge Elimination System authorized by P.L. 92-500. Another is through more comprehensive approaches, exemplified by Section 208 of P.L. 92-500, that give responsibility for planning and implementing environmental controls and management systems to state and local authorities with EPA providing guidelines and assistance.

The Waste Management Subprogram is designed to support efforts by EPA and state and local governments to develop and demonstrate specific pollution control technologies and management systems. It provides methods to assess local problems and to select appropriate management options for control. This subprogram is organized as follows:

- Wastewater Management
    - Wastewater Treatment Technology
    - Soil Treatment Systems
    - Urban Runoff Pollution Control

- Solid and Hazardous Waste Management

Wastewater Management--

The objectives of the Wastewater Management activities are to develop the technology to support the Agency in meeting the goals of P.L. 92-500, which are to meet secondary treatment requirements by 1977, to achieve fishable-swimmable water quality by 1983 and to eliminate the discharge of pollutants by 1985. The major implementation actions to achieve the goals are directed in the Agency water strategy plan as follows:

Municipal Construction Grants Program -- Provide financial assistance for the construction of publicly owned treatment works (POTW) in a cost-effective manner and with priority for implementation in water quality limited areas.

Water Quality Management Planning -- States and areawide 208 planning authorities will update existing plans, provide coordinated management decisions, and strengthen the institutional basis for water quality management. Plans should be completed by November 1978. They will coordinate permit requirements, construction grant needs, nonpoint-source programs and identify technical, institutional and funding problems and solutions. They will consider the social, economic, and environmental consequences of alternative proposals.

Toxic Pollutants -- To meet the 1983 goal major attention will be paid to toxic pollutants such as refractory organics and heavy metals. There is a need to establish required limitations on discharges of identified toxicants. A coordinated effort of research into toxic pollutant treatment technologies and management systems, health and ecosystem effects and their fate in the environment, will be used with the Act's various regulatory provisions to produce an integrated Federal water-borne toxicants policy.

Permits, Compliance Monitoring and Enforcement -- Permits have been issued to meet the 1977 requirements. By law no permit term exceeds five years. Permit renewal is likely to include storm sewer discharges.

Nonpoint Sources (NPS) -- The NPS control will become a major program emphasis, to be implemented through the water quality management system. It is recognized that many types of nonpoint sources are not amenable to an effluent limitations approach. In developing individual solutions, designated agencies will identify best management practices for these sources.

To support the strategy, ORD's Wastewater Management research is subdivided as follows:

- Sludge processing, disposal and utilization;
- Improved performance, and economics of treatment;
- Soil treatment systems;
- Management of small wastewater flows;

- Urban combined sewer and stormwater control;
- Toxics control;
- Advanced treatment for higher water quality;
- Wastewater reuse and pollutant discharge elimination.

The following discussion presents a research plan to assist the Agency strategy for attaining the national water quality goals.

During the FY 1977 - FY 1981 period this group of activities will emphasize bench and pilot-scale development and evaluation and assessment of existing full-scale systems. It will not include a demonstration program. To the extent possible, research and development will be coordinated with construction grants projects which include pilot-scale technology evaluations. Much of this research will require the coupling of health and ecological effects studies with alternative control technology evaluation and assessments.

Wastewater Treatment Technology--Basic knowledge of sludges and their behavior environmentally limits the effective application of existing sludge processing and disposal technology as well as encourages the implementation of expensive current technology. Continuing work to provide improved understanding includes the following categories:

- Characterizing the changes in form and the fate of contaminants, such as heavy metals or specific organics or the survivability of pathogenic organisms and the transformation and transport mechanism of these specific contaminants and pathogens within the disposal technology, especially as related to land disposal.
- Developing quantitative understanding of mechanisms controlling conditioning of solids (chemicals, heat, etc.) for reliable and efficient solids-liquid separation.
- Investigating the mechanisms controlling useful product formation (methane gas, fuel gases, chars, etc.) in order to maximize formation of product and minimize energy consumption.

Other work also will include continued research of improved approaches for new dewatering equipment capable of producing an auto-thermal cake, incineration and pyrolysis equipment, and for stabilization of sludges during processing and disposal. Finally, the overall methodology for cost-effective managing of sludge processing and disposal will be developed and distributed to the users. Work on sludge management has received major support for several years and is expected to continue with emphasis on approaches which reduce energy consumption.

The relationships between operation and maintenance (O&M) practices and performance in terms of secondary effluent and other effluent standards will be developed. This effort will continue for several years. It is necessary to determine which factors in O&M have potential for the greatest cost reduction and improve performance. Emphasis in this area will be on small plants where O&M costs are high per unit of production. Research on the relationship between plant reliability and O&M is just beginning and is expected to continue throughout the five year interval.

The instrumentation and process control long-range work features the completion of the development and evaluation of methods for process control of conventional plants. The work includes assessments of instrumentation capabilities and limitations, development of selected sensors to measure constituents such as ozone in water and on-line toxic analyzers together with the corresponding controls employing the sensors for improved plant operation. At current resource levels the work will extend beyond five years.

The research at current resource levels in improved engineering design and construction practice will feature continued assessment and development of new methods and materials for use in construction. The work on assessing design, cost and energy requirements for alternative control technology will also continue and provide inputs to planners and engineers in selecting most effective technology. The work will continue through the five year interval.

Research will be carried out to assess the magnitude of the problem of toxics control prior to developing specific technological solutions. A data base must be developed to evaluate the relative effectiveness of pretreatment versus in-plant control technology strategies. Research will focus on characterizing the interacting physical and chemical mechanisms contributing and controlling the removal of toxicant during the normal process of treating wastewater. Development of control technologies will proceed along with methods for assessing pretreatment versus in-plant removal versus extraction from sludge versus controlled disposal practices.

The ongoing work on upgrading methods and nutrient removal processes will be finished and phased out. Work on disinfection alternatives will continue through the period with evaluation of appropriate alternatives. Work on new cost-effective technology will continue with development and evaluation of potentially cost-effective techniques, such as deep shaft aeration, oxidation ditch process and fluidized bed oxygen processes.

Research in wastewater reuse will not include technology development or demonstrations. The only activity would be completion of a study to assess the extent to which the U.S. population is now drawing water for domestic purposes from sources receiving upstream wastewater discharges and characterization of organics in wastewater effluents.

In the small wastewater flows activity it is expected that improved methods for operating soils systems will be completed within five years and work on this topic will be discontinued. Similarly, it is expected that the effectiveness and costs of pressure and vacuum collection systems will be completed and no further studies will be required. Development of new systems such as the novel evapotranspiration system will be continued. Studies of methods for handling septage will be continued for several years. Study of water-saving devices will also continue. Emphasis will be shifted from the single-home waste to recreational wastes and non-sewered commercial wastes.

Soil Treatment Systems--In the Soil Treatment Systems Plan presently being implemented, priority is given to completion of the required data for development of the irrigation mode. Equal importance is given to research in those areas relating to mechanisms and effects which are common to all types of soil treatment systems. As resources permit, development and evaluation of infiltration-percolation and overland-flow systems will be continued. It is expected that this plan will provide acceptable planning and design criteria for irrigation systems; information for design and operation of infiltration-percolation systems with limitations due to climate, soil, and other variables; and reasonably reliable design data for overland-flow systems for the southern half of the United States by 1893.

Urban Runoff Pollution Control--The program objective of obtaining wet weather pollution abatement decision-making information will receive primarly emphasis. A quantitative problem assessment and receiving water impact ranking along with identification of key pollutants as a function of source and receiving water type will be developed. This will be used to determine the degree of control required and determining wet weather water quality standards. The other elements of decision-making information needed are cost and performance. A long-term effort in developing and evaluating best management practices will be initiated for sewered and unsewered runoff, while a moderate effort will be continued to develop less costly structural or treatment methods for both combined and storm sewers. The ultimate objective is to produce a manageability index which will incorporate integrated approaches and give cost and performance of combinations of non-structural and structural methods; land management; minor urban flood control; multi use systems; and best management practices.

Solid and Hazardous Waste Management--

Municipal officials rank solid waste management as their most pressing problem. Approximately $5 billion is spent annually on collection and disposal of solid wastes, and yet less than half of the generated waste is collected. Most of that which is collected is disposed of in open dumps. The Agency estimates that only 5% of all disposal sites meet acceptable environmental standards.

Much is not known concerning proper disposal of wastes in land. Even the current best practice "sanitary landfilling" technique may not be the best technique for land disposal. Current "sanitary landfill" practice restricts the flow of water into the landfill to minimize the amount of leachate produced; however, this also retards the decomposition and stabilization of the landfill and may result in moral and financial responsibility for maintenance of the landfill for generations. With knowledge of decomposition under differing moisture regimes and the development of techniques for collecting and treating leachates, rapid stabilization could likely be effected in a relatively short time and the land can be put to use for other constructive purposes. Major deficiencies in knowledge pertinent to landfilling include rates of decomposition, leachate and gas production under different moisture regimes; migration and attenuation of the products of decomposition and of the soluble organics and inorganics through various soils; the use of natural soils, additives and synthetic barriers for preventing leachate movement; cost-effective methods for treating leachates; the pollution potential of hazardous materials (including wastewater treatment and air scrubber sludges) disposed of in landfills; the patterns of gas migration and methods to control this migration; and practical methods for preventing environmentally unacceptable land disposal sites and taking remedial action.

Current estimates indicate that 30-35 million tons of hazardous wastes are disposed of to the ground with no controls, no records as to location quantity and composition. At the present time, proven techniques for large scale disposal of most, if not all, hazardous wastes are not available and generators of these wastes have little incentive to expend resources for adequate management. Major deficiencies exist in such areas as thermal decomposition, treatment, chemical stabilization, encapsulation, concentration and fixation.

The Nation's nonrenewable resources are being depleted. Waste management practices account for the disposing of some of them in landfills. Common sense would indicate that resources should be recovered and put back into use, but current resource recovery technology is not always economical. A resource recovery system that recovers papers, metals, and glass cannot at the present time be supported economically without first developing useful marketable and valuable products from the organic material in the municipal solid waste (MSW) which is left after the papers, metals and glass have been separated. Present thinking is to convert this organic material to fuel or energy.

Approximately 75% of the costs to municipalities for solid waste management is associated with waste storage, collection and transportation. This area of effort often receives priority over disposal because of the magnitude of the costs involved. Development of approaches will be of great benefit to municipalities.

Municipalities and other governmental agencies need criteria for site selection, bases for design and operation of landfills; guidance on the efficiency of hazardous waste processing; new and improved systems for storage, collection and transportation of solid waste; and, improved technology or methodology for waste reduction and the recovery and reuse of waste materials.

Accordingly, ORD research objectives for this problem area are as follows:

- Development of methodology and/or equipment to eliminate effects due to the release into the environment of materials present in solid and hazardous waste which would be adverse to public health and welfare.
- Evaluation, development, and demonstration of new or improved management techniques, new or improved methods of collection, storage, transportation, and disposal.
- Evaluation, development and demonstration of new or improved methods for the reduction separation, processing and recovery of resources, including energy.
- Establishment of a technical base to support the Agency's efforts in developing guidelines for solid and hazardous waste management.

During the FY 1977 -1981 period, comprehensive data on landfilling will be obtained on the characteristics of municipal and hazardous wastes, leachates from these wastes, decomposition rates under varying moisture regimes, the attenuation of pollutants, and the migration of gas in soils. In addition, liner materials, natural and synthetic, for controlling leachate movement will be evaluated and methodology will be developed to control gas movement. Research effort will be conducted primarily through laboratory and pilot studies with some field testing or verification of laboratory based results. In culimination of this research, guidance documents will be published for site selection, design, maintenance and operation and site closing.

Alternative methods of disposal of solid and hazardous wastes will be evaluated. Technical and environmental data will be developed and guidance documents produced to provide a basis for logical engineering decisions on the most viable alternative methods to landfilling for environmentally sound disposal of wastes to land.

In the treatment of hazardous wastes, research is to provide technical, environmental, and economical assessment of biological, chemical and physical treatment processes that appear applicable for homogeneous and heterogeneous hazardous waste streams. New methodology will also be developed. Processess evaluated or developed will include techniques for detoxification, encapsuation, concentration and fixation.

Efforts in resource recovery research will endeavor to reduce technical and economic risks associated with resource recovery implementation. Specific areas of research will include the upgrading of pyrolysis products, evaluation of preprocessing equipment and systems, and the development of specifications for recovered products.

Potential Subprogram Growth Areas--

Additional research is desirable to adequately address mid-term Agency needs and to initiate work on longer range issues addressed in existing legislation.

Mid-term emphasis for growth would be dedicated towards the follows tasks:

- Resumption of alternative treatment processes for ocean outfalls.
- Timely completion of an in-house pilot test and evaluation facility capable to:
  - -provide independent and quick evaluations of treatment concepts for municipal wastewaters and sludges;
  - -determine scale-up factors prior to field demonstrations;
  - -determine limits of process capability through failure mode analysis;
  - -determine specific pollutant removal capabilities;
  - -make cost-effective comparative evaluations;
  - -develop and test automated process control systems;
  - -respond to Regional Construction Grants Program needs.
- Participation with initial Construction Grants projects to provide quick, complete and direct technical assistance capability.
- Expand and accelerate land application alternatives and means of upgrading of existing facilities.
- Expand to a meaningfull level of effort research in joint industrial-municipal treatment limitations to define pretreatment requirement.

Research which can also be expanded or initiated in the five year period FY 1977 - FY 1981, having mid- to long-term impact on the Agency municipal wastewater strategy would be in the following areas: comprehensive planning, sludge management with emphasis on accelerating the solutions to conversion technology, disenfection and land disposal site management and problems including support of health and ecological effects where necessary; new upgrading technologies such as addition of powered carbon to aeration basins and digestion processes; land application technology in a more complete assessment of systems in the northern climates; pretreatment programs and toxics strategy development and assessment capabilities; the assessment of selected processes for ocean discharges; and a small effort to initiate an integrated community services and environmental control program that would provide communities with technological solutions for on-site integrated utility and environmental control systems. During the latter part of this five-year program funding would be concentrated in demonstrating cost-effective solutions for novel sewering and treating waste from small groups of homes and expand technical assistance and assessment activities; and urban runoff control with emphasis on developing design criteria for best management practices.

Virtually no projects have been funded for basic laboratory research in support of municipal wastewater technology laboratory in the past five to seven years. In order to improve the base of science and technology for solving future problems basic research studies would be restored to about ten to fifteen percent effort of the total program.

The efforts in resource recovery from solid and hazardous wastes would be expanded to include new product development and to allow the evaluation of selected resource recovery projects or systems.

Water Supply Subprogram

Only in the last few years have instrumentation and analytical techniques been able to detect and measure very small quantities of contaminants in drinking water. With this equipment, the discovery of organic materials in much of the Nation's drinking water contributed to the enactment of P.L. 92-523, the Safe Drinking Water Act. The Water Supply Subprogram supports implementation of this Act by EPA and the states.

The objective of this subprogram is to develop the scientific criteria and treatment technology for assuring safe drinking water and protecting the Nation's water supplies. The following questions must be answered in order to attain that objective:

- What substances occur in a widespread number of drinking water supplies and are potentially harmful to human health?
- What are the effects of these substances on human health?
- What analytical procedures should be used to monitor water to assure that drinking water standards are met?
- Because some potentially harmful substances may be formed during transport, storage, treatment and distribution, what changes in these practices are required to minimize their formation and effects?
- What treatment technology must be applied to reduce contaminant levels?
- What are the by-products (and their effects) of that treatment technology?
- How can underground sources of drinking water be protected from contamination?

The research addressing these questions can be grouped into four areas: health effects, treatment technology and systems management, identification and measurement, and groundwater management.

Contaminants being addressed include organics, inorganics (including asbestos), and microbiological contaminants. The largest area of ignorance is with the long-range potential harmful effects from trace organics, so approximately 45 percent of the total funds will be directed toward determining and controlling that problem. The second highest priority is the relationship of inorganic contaminants to health, so a large effort (about 20 percent) will be made in this area. This is especially true regarding the difference in the incidence of cardiovascular disease for those consumers that drink hard versus soft water. Microbiologic contaminant occurrence, monitoring, effects and control remain relatively high priority relative to public health, because outbreaks of waterborne disease still occur in the United States, especially in areas served by poorly operated distribution systems.

Water Supply Health Effects--

The largest emphasis will be on determining the health effects of organics identified as prevalent in the National Organic Monitoring Study, which will be completed in September 1977. That Survey concentrated on analyzing for 20 specific organic compounds, selected because they have been reported in some source or treated waters, have a known or suspected toxicological effect and can be analytically quantified. As the results from the Survey show which contaminants are prevalent in finished drinking water, the literature on the toxicity of these materials will be re-examined. Efforts up through FY 1977 include preliminary data on the mutagenic and carcinogenic activity of organic mixtures from tap water, comparative metabolism data on the halo-ethers to determine the most appropriate model for extrapolating health effects data from animal to man, data on whether chlorobenzenes and bromobenzenes can influence the toxicity of other foreign organic compounds, and data on the influence of sex difference and strain on the toxicity of chloroform.

Current and continuing studies are being conducted, in collaboration with other Federal agencies, to determine any relationship between cardiovascular disease and hypertension, and various inorganics in drinking water, including sodium, barium, cadmium, calcium, magnesium, lithium, iron, lead, zinc, copper, arsenic, selenium, and some corrosion products. Preliminary reports on sodium, barium, arsenic, and selenium are expected in FY 1977. Efforts to determine the carcinogenicity and cocarcinogenicity of asbestos when ingested will also continue. Outbreaks of waterborne disease will be investigated to identify preventive measures, and an attempt to determine infective dose levels of viruses for humans will be continued.

Treatment Technology and Systems Management--

The lack of firm health effects data for organics does not relieve the Agency's responsibility to prescribe treatment when a reasonable doubt exists and monitoring is not practical. Pilot plant and larger scale studies thus are continuing on the formation and removal of the four trihalomethanes that have been shown to occur widely where chlorination is practiced and that are potentially toxic. Unit processes such as granular activated carbon beds, powered activated carbon, macroreticular resins, ozonation, and chlorine dioxide will also be studied to determine their capabilities to remove specific organic contaminants within reasonable economic limits. The contaminants have already been selected for study based on the existing data collected in the ten-city National Organics Reconnaissance Survey. This list will be expanded to include additional compounds which may be discovered in the current Survey as candidates for future control.

Work on inorganics will focus on treatment technology that small water utilities can use, especially to reduce fluoride, arsenic, nitrates, and selenium. Research on cost of treatment, including that of sludge disposal, for removal of radionuclides will be completed.

Several efforts on microbial contaminants will be completed in FY 1977. This includes investigations of the effects of various parameters on disinfection efficiency, with emphasis on inactivation of viruses. Alternative, faster indicators of disinfection efficiency are also being sought. An evaluation of ultraviolet, ozone, chlorine dioxide, and chlorine as disinfectants for small systems will be completed.

Identification and Measurement--

Research will proceed along three lines to develop techniques for monitoring general organic parameters (groups of compounds), specific organics which are widely distributed and may have health significance, and unit processes for organics removal effectiveness. Both short-term evaluations of current techniques and long-term improvements will be pursued.

For inorganics monitoring, multi-element analysis techniques (both field and laboratory) will be emphasized, as well as continuing efforts to improve sample collection, shipping, storage, and preparation for asbestos fiber counting. Work will also continue to improve and standardize asbestos fiber counting methods.

Methods for identifying and measuring microbial contaminants in water supplies are also being evaluated and improved. A search for organisms which will provide better indices of drinking water quality will continue. A tentative standard method for detection of enteroviruses will be evaluated and an interim report prepared. Efforts will continue to develop a method for isolation of the "hepatitis A virus".

Groundwater Management--

The overall objective of this area is to determine ways of protecting underground water supplies from contamination. Work will continue in three general areas. The major thrust will begin to develop control criteria for some 26 general avenues which have been identified for the introduction of pollutants to underground waters. Efforts will continue in describing the subsurface environment as a receptor of pollutants by developing new drilling, sampling, and analytical technology directed primarily at organic and microbiological parameters. In order to address more immediate problems, work will be directed toward the consequences of recharging groundwater with treated municipal wastes.

Present plans for FY 1977 - 1981 are that efforts in measurement and identification programs will focus on development of practical techniques to identify, measure, and determine sources of contaminants (particularly organic substances and microbial agents) in drinking water. Techniques will be designed for use by state and local officials responsible for safeguarding public drinking water supplies.

Defensible health effects data for organic, inorganic and microbiological contaminants of drinking water will be developed through short and long-term toxicological studies and comparative epidemiological studies. Current plans will be evaluated and redirected as necessary when the evaluation by the National Academy of Sciences of health effects of contaminated drinking water, as required by P.L. 93-523, is completed.

Studies will be continued or initiated on removal and inactivation of cadmium, lead asbestos, nitrate, fluoride, organic compounds, bacteria and viruses. The EPA intends to continue development of techniques for preventing water quality deterioration while distributing drinking water. Technology applicable to small water supply systems will be emphasized. There will be a substantial R&D effort on controlling organic contaminants in drinking water. Halogenated organics formation mechanisms in normal disinfection practices will be determined and control methods developed. Chlorine disinfection alternatives will be thoroughly studied in the near-term. Candidate alternative disinfectants are chlorine dioxide, ozone, and ultraviolet light.

Increased efforts are planned on removal and disposal of organics. Also in FY 1977 - FY 1981, studies will continue to provide waste disposal site-selection criteria and information on control of groundwater pollution.

The National Academy of Sciences report, due March 1977, may identify additional future research needs in the area of health effects of drinking water contaminants. The report will also require consideration by EPA of the economic and technological feasibility of implementing the recommendations. The report, however, is not available now and the impact of the report on research requirements cannot be evaluated accurately at this time.

Potential Subprogram Growth Areas--

Increased efforts for FY 1978 and beyond could be directed toward accelerated determination of the occurrence and carcinogenic potential of organic and inorganic concentrates from tap water through in vivo and epidemiological studies; determining the relationship of cardiovascular disease (particularly hypertension) and drinking water quality; providing full-scale evaluation of treatment processes to avoid formation of or remove contaminants and scale up carcinogen removal techniques from bench to full-scale; describing costs of control methods and investigate new technology for and reduction of costs to small systems; and expanded extramural efforts to evaluate, improve, and develop both field and laboratory identification and measurement techniques.

The increased efforts would allow epidemiologic studies of greater scope; field evaluations of control and treatment technology at a level to produce definitive cost data; and a major cost reduction effort addressed to small systems.

Environmental Management Subprogram

EPA's legislative mandates generally delegate authority to state or designated regional and local agencies to implement requirements of Federal environmental quality programs. Included in these requirements are development of areawide and continuous planning processes (P.L. 92-500 (FWPCA) Section 208), water quality facilities plans (FWPCA, Section 201), solid waste disposal plans (Solid Waste Disposal Act (SWDA), Section 207), state air quality implementation plans (Clean Air Act (CAA), Section 110) and plans for air quality maintenance. To implement these programs, environmental agencies at state, regional and local levels are required to analyze regional development objectives, population, and economic growth projections, land use and transportation patterns for direct and indirect effects on environmental quality.

Selection of environmental protection strategies having broad public acceptability is becoming an increasingly difficult task. State, local and regional institutions often lack adequate methods to analyze and evaluate alternative strategies and to develop coordinated procedures based upon a chosen strategy. Such agencies may also lack the resources necessary to formulate feasible solutions to their environmental problems as such large undertakings have not been common in our history. In addition, appropriate methods are often not available to analyze the scope of problems faced on a regional basis.

The objective of the Environmental Management Subprogram is to provide regional environmental planners and managers new and improved methods to determine feasible alternative solutions to comprehensive environmental problems and to develop techniques to select least-cost solutions. The research focuses on development of improved multimedia planning methods; improved methods for collection and analysis of environmental quality and economic information, and for the evaluation of alternative institutional arrangements; and the development of comprehensive systems analysis and evaluation methods for particular engineering-management systems. Specific efforts include:

- The design of integrated multi-media environmental management systems, including analytical planning and alternative implementation techniques. In addition to direct application of control technology changes in administrative and institutional factors such as organizational and indirect controls will be examined.

- Development of technical guidance for applying available state of the art methods in assessing problems and selecting available management options, to aid local planners and policy-makers in their decision-making.

- Evaluate alternative methods of portraying environmental options and costs to the public to assist them in making enlightened judgments to the planning and implementation process.

- Development improved socioeconomic impact measurement methodology to permit objective assessment of multimedia problems and evaluation of remedial measures.
- Evaluate alternative methods of assessing and enforcing environmental quality programs. Greater emphasis would be placed on the assessment of human health and other "welfare" effects as well as distributional impacts.

The outputs will be user-oriented and will include information needed and decision methodology required to select and implement effective environmental quality control programs on a community and regional level.

The five year objectives of the Environmental Management Subprogram are divided among six definite areas of concern: 1) Integrated Assessment, 2) Socioeconomic Research, 3) Planning Assistance, 4) Institutional Analysis and Policy Research, 5) Evaluation Research, and 6) Anticipatory Research. The guiding principle in all research investigations will be the definition and quantification of interrelationships in environmental quality situations. User-oriented information and methodologies will be stressed with particular concern for approaches which can be applied at the implementation level as well as in the context of an overall analysis.

Integrated Assessment--

Integrated assessment involves comprehensive analysis of the tradeoffs between direct technological and indirect or nontechnological options, and among economic, social, and environmental impacts in a regional context. The methodology commonly applied to such analyses has been the large-scale, input-output type modeling approach. While many of these comprehensive methods have been developed, their utility in planning/implementation level decision-making is questionable. The primary objective under integrated assessment research will be the continued development, application, and vertification of the Environmental Systems Analysis Program (ESAP). This major research effort will be aimed at providing design level methodologies for formulation of management and design alternatives for the treatment, air quality control, residuals management, and stormwater management. The ESAP will take the form of a series of detailed procedures, methodologies, and models which are linked in an analytic framework which optimizes intermedia and socioeconomic impacts of design-level decisions.

Socioeconomic Research--

The socioeconomic research element will be aimed at quantifying the socioeconomic impact of environmental quality control decisions. Particular emphasis will be placed initially upon the development of a baseline approach for socioeconomic analysis. This approach will serve as a "standard method" upon which to base subsequent detailed socioeconomic research studies, and to guide community and regional planners, and other researchers in the conduct of coherent and mutually comparable socioeconomic analysis. Sepcific socioeconomic studies will be aimed at quantiying social and economic benefits as well as costs of pollution control decisions on a scope and level of detail commensurate with that of the Environmental Systems Analyses Program

Planning Assistance--

The objectives of this research element are to combine all elements of the Environmental Management Subprogram into useable packages of information. The element will involve a continuing effort to establish and maintain close contact and working relationships with in-the-field engineers, planners, and municipal officials responsible for the evaluation and implementation of environmental management programs. The research output will be designed to fulfill an information transfer function aimed at placing the output of the program in the hands of users through the use of manuals of practice, seminars, and hands-on demonstration and evaluation of methodologies in the field. Included in this area are revisions of the Areawide Assessment Procedures Manual and the Regional Environmental Management Handbook, the development of an ESP Users Manual, and the sponsorship of a series of continuing Environmental Management Seminar/Workshops.

Institutional Analysis--

This element is designed to analyze existing and necessary instituional arrangements for implementing environmental management programs. Overall improvement in environmental quality will occur only to the extent the alternatives which are analyzed and determined cost-effective can be effectively implemented. This element will develop methods for classifying and analyzing the capacity of existing institutional arrangements for implementing environmental management programs. Approaches for modifying inadequate framework and for developing new institutional mechanisms will be studied.

Specific research studies will be conducted in the area of environmental quality and public involvement to determine and quantify the factors which govern the nature and magnitude of public involvement in environmental management decisions in various geographical and institutional contexts. Research is particularly needed in the area of increasing public involvement in stimulating constructive changes in existing institutions and implementing environmental ethics of communities.

Evaluation Research--

Evaluation research will concentrate on applying the output of environmental management studies to real world situations, to test the effectiveness of socioeconomic analysis, modeling approaches, institutional frameworks, and environmental management control systems in meeting their intended objectives and satisfying the needs of users. Much of this work will be conducted in the Environmental Management demonstration program which will be initiated in late FY 77. Evaluation research will serve the function of a "quality control" measure of Environmental Management research and will quantify the accuracy, sensitivity, and potential impacts of its use.

Potential Subprogram Growth Areas--

Continuing budget constraints have precluded any long-term, anticipatory, or exploratory research in this program. If a modest annual increase were authorized over the next five years, the aforementioned areas would be generally extended in scope, but a bonafide program of anticipatory research could be developed.

This effort would seek to identify key environmental policy issues which will arise in the future as a consequence of anticipated changes in such things as life style, energy supply and demand, climate and non-renewable resource activities, and social reform. It will seek to forcast the nature and magnitude of future environmental problems based on trends in industrial and agricultural technology, population dynamics, and secondary impacts of current environmental policy. The program will also engage in research into new concepts in urban design and management to optimize environmental quality, including integrated utility systems, the melding of environmental quality considerations into urban planning concepts; and the integration of environmental management into the total institutional framework of community management.

INDUSTRIAL PROCESSES PROGRAM

The Industrial Processes Program is responsible for developing improved methods for reducing or eliminating environmental quality problems associated with all types of industries (except energy industries discussed subsequently in the Energy/Environment Program). Research covers both point-source pollution; e.g., metal production and processing, pulp and paper production, food processing, chemical manufacturing, and metal finishing; and nonpoint-source pollution, such as that from agricultural and timber harvesting operations.

The program is multimedia in that it considers all pollutants, airborne, waterborne, or in solid form. For example, in the food processing industry, process ammonia waste may be discharged into the air, or it may be "scrubbed" from the air and discharged in wastewater. In either form, the pollutant must be controlled. Another example is arsenic waste from non-ferrous metal smelting, which may appear as an air pollutant, a water pollutant, or a solid residue. Research objectives seek a total solution to the arsenic pollution problem, which protects all environmental media.

For a given problem, the program proceeds from assessment to inventorying, and then to development of control strategies. For example, electroplating of metal results in toxic wastes such as chromium, cadmium, and other heavy metals, and there are over 20,000 electroplating establishments in the U.S. Solution of this environmental problem requires research on the nature of the waste, information on the geographical distribution of the facilities, and, finally, development of cost-effective control technology and strategies.

Another example of assessing, inventorying and controlling pollution is in the drycleaning industry. A variety of solvents (including halogenated hydrocarbons) are used for cleaning fabrics. There are approximately as many drycleaning establishments in the U.S. as gasoline stations, and they are almost as widely dispersed. Residual solvents from fabrics are released to the air, and spent solvents are frequently dumped on the ground to evaporate. For this problem, the range of different solvent types is determined, the geographical distribution of facilities by type of solvent use is assessed, and then cost-effective control strategies are developed. For larger facilities, onsite solvent recycling is being explored, while for small plants, cooperative solvent collection and recailming services serving many plants appear to be a cost-effective strategy.

The program is divided into two subprograms: Renewable Resources Industries and Minerals, Processing, and Manufacturing Industries. The Renewable Resources Industries Subprogram includes all food and fiber production activities. The Minerals, Processing, and Manufacturing Industries Subprogram includes mineral extraction and all other manufacturing activities except energy-related mineral extraction, processing and utilization activies discussed later in section II. Pollutants emanating from renewable resources industries tend to be dispersed in nature, being caused primarily by wind and rain erosion of materials such as sediment, fertilizer, pesticides and manure from the land surface. Pollutants from other private sector activities, however, are normally discharged from point sources, such as stacks and outfall pipes. Because of these fundamental differences, there is little comparability between environmental protection concepts of the two subprograms, the renewable resource research area requiring the skills of agronomists, agricultural engineers, hydrologists, soil scientists and civil engineers, while the manufacturing research area relies principally on chemical, sanitary, and mechanical engineers and chemists.

The Minerals, Processing, and Manufacturing Subprogram provides principal scientific and technical support for the control technology requirements implemented through the various Federal environmental laws, especially air (P.L. 91-604), water (P.L. 92-500) and toxic materials (P.L. 94-469). This support is manifested in problem assessments, research, development and demonstration of more efficient and effective pollution control alternatives, including final effluent treatment, manufacturing process changes, or production materials changes. In addition to routine environmental controls, this subprogram also includes research on methods for preventing and controlling accidental spills of hazardous materials and methods for safe, effective recovery and removal of the spilled substances.

Research, development and demonstration activities over the past decade have resulted in dependable technology for removing the majority of common pollutants from effluents and emissions from minerals, processing, and manufacturing industries on a weight basis. In the next five years, the program will be directed to eliminating the remaining environmental emissions which, although insignificant on a weight basis, may be environmentally significant due to their toxic or hazardous characteristics.

The Renewable Resources Industries Subprogram develops information on the activities and natural processes involved in environmental degradation caused by the food and fiber producing sectors of private industry, and develops effective and efficient control technologies and management practices to minimize pollution from these dispersed or nonpoint sources. Whereas controls on the minerals, processing, and manufacturing industries are enforced primarily through effluent and emission permits for point sources, enforcement of nonpoint-source limitations rests primarily on regionally specific management practices which are designed to meet ambient air and water quality standards. These recommended management practices are derived from comprehensive regional planning analyses, such as those authorized by Section 208 of P.L. 92-500 (Federal Water Pollution Control Act).

The level of knowledge of pollution processes and control methods in the renewable resources category is much less sophisticated than in point-source categories. Procedures for estimating water pollution impacts from various standard agricultural and forest management practices have been developed, but in many cases have not been adequately field tested. Further, although several new control methods have been developed, the functional relationships between various levels of control and resulting water quality improvement in streams are still very imprecise. Because many control procedures require changes in traditional practices, and fully coordinated regional approaches, the socioeconomic and institutional problems of implementation are more difficult in this area of environmental protection research.

Renewable Resources Industries Subprogram

It is now well established that in many parts of the Nation, even with the application of best available treatment technology to all point sources of pollution, anticipated water quality goals cannot be attained because of the contribution of pollutants from nonpoint sources (NPS) such as renewable resources production activities. The major activities comprising renewable resources include crop production on both irrigated and nonirrigated lands, forest management, animal production and integrated pest management.

Further, the expectation is that pressure will mount for the U.S. to significantly increase agricultural and forest production in the last quarter of this century, as demands of highly populated, underdeveloped countries increase, developed countries attain increased affluence and world population increases. Environmental problems of a broad scope are likely to accompany any drastic efforts to increase agricultural production in the U.S. Moreover, significant conflicts may arise between energy development, production and uses, community development and renewable resources activities. Consequently, the long-term problem for the U.S. will be to increase agricultural and forest production with minimal environmental degradation and minimal conflict with other national goals.

In order to develop a basis for selecting and justifying local management techniques for controlling nonpoint source pollutants related to agricultural and forest production, it will be necessary to accomplish the following tasks:

- Provide tools for the State and local planner/decision maker to determine the probable environmental consequences of the major agricultural and forestry pollutants, including appropriate predictive methods.
- Provide tools to evaluate the cost-effectiveness of individual and combined pollution control management systems.
- Identify cost-effective best management practices (BMP's) that minimize agricultural and forestry pollution by evaluating and testing different BMP systems at different locations.
- Develop, evaluate and demonstrate implementation strategies (including their socioeconomic and institutional aspects) for candidate BMP's.

Methods to control or manage wastes and runoff from specific agricultural and forest sources for limited areas of the Nation have been developed. However, in most cases, best management practices have not been identified and evaluated for the local levels. Guidelines and manuals that identify alternative methods for controlling specific pollutant problems have been developed and published in some cases. Handbooks and planning tools that can be used by the regional planner are also just beginning to emerge from the R&D program. These, however, are initial thrusts at the solution of the problem and will necessitate refinement.

The linkage between best management practices and resultant water quality in the stream is still largely unknown. The socioeconomic and institutional aspects of implementing BMP's is another critical area where research is needed. State-of-the-art information on loading functions for different kinds of agricultural and forestry practices is available, but many have not been verified and field tested. Because of this lack of complete information, it is difficult to quantify cost-effectiveness of alternative practices and identify optimal watershed management strategies.

The renewable resources research program is structured to enhance understanding of problems and to develop the kinds of tools needed to control environmental pollution associated with agricultural and forestry production. This research program is closely coordinated with the U.S. Department of Agriculture, U.S. Department of Interior, and Universities and private industry. The program encompasses the following aspects:

Assessment and development of total management systems, including best management practices and pollution control predictive methodologies to control water, land, and air pollution from the production and harvesting of food and fiber and their related residual wastes.

Assessment of probable trends in the production of renewable resources and their resulting environmental and socioeconomic impacts.

Development and testing of integrated pest management systems to reduce the use of chemical pesticides and thereby minimize potential environmental degradation and hazards.

Research conducted on a near-term basis is essential to support development of guidelines for identifying and evaluating the nature and extent of agricultural and forestry nonpoint sources of pollution, along with the necessary processes, procedures, and methods to control pollution from these sources, as required under Section 304 (e) of P.L. 92-500, the Federal Water Pollution Control Act Amendments of 1972. The tools are needed to support State and local agencies in the execution of their areawide waste management responsibilities under Section 208 of the FWPCA.

The Agency also has responsibilities under the Federal Insecticide, Fungicide and Rodenticide Act to regulate the use of pesticides that may enter aquatic ecosystems through NPS discharges. Research is therefore being conducted on pesticide modeling and crop management practices, and on integrated pest management strategies to optimize the use of chemical and non-chemical means for controlling pests with the goal of minimizing dependence on chemical pesticides.

The purpose of long-term research in the renewable resource area is to develop the capability to assess and predict environmental effects of existing and advanced approaches to increased production; to assess the resulting resource levels, socioeconomic trade offs and interactions at local, regional, and national levels; and to develop new and improved cost-effective technological, management and institutional approaches to assure the implementability of control options while considering the demand for increased production at minimum environmental impact.

The Renewable Resources Industry Subprogram concentrates on five activities: nonirrigated crop production, irrigated crop production, animal production, forest management and integrated pest management.

Nonirrigated Crop Production --

Emphasis in this area is concentrated on tools to assess and evaluate pollution resulting from existing agricultural practices and methods to determine the cost-effectiveness and socioeconomic aspects of alternative management systems to minimize pollution from nonirrigated crop production activities. Pesticide and plant nutrients runoff control is of prime concern. Special consideration will be given to development and assessment of socioeconomic and institutional aspects of BMP implementation strategies. Efforts will be increased on the assessment of environmental impacts resulting from new trends in food production and on the development of methods to evaluate trade-offs which can conserve critical resources, including energy.

Irrigated Crop Production --

Research on the management of pollutants resulting from irrigated crop production is focused on the topics of evaluating the benefits to crop production and to water quality improvement by decreased water usage, improved timing of application, and by structural means such as drainage and channel lining. Additional work is being done on methods to reduce sediment, nutrient, and pesticide losses during irrigation and on identifying the constraints to adoption of improved irrigation practices such as legal, institutional, and economic factors. Since adoption of these newer management practices is highly dependent upon convincing irrigated crop producers of their workability, field evaluation in various geographical regions will continue to be important.

Animal Production --

Research on managing wastes from animal production will emphasize the development of waste handling techniques and methods for the smaller farmer as well as for the larger concentrated feeding operator, with application of the manure to cropland as the primary goal. Projections of increasing scarcity and higher prices of natural gas, and the synthetic fertilizers manufactured from them, dictate that the nutrients in animal wastes will assume increasing importance. Studies will be directed toward minimizing potential environmental effects from this and other reuse schemes.

Forest Management --

The focus in this area is on the assessment, development, demonstration and evaluation of management methods and planning tools that can be used to mitigate adverse environmental impacts of forest management activities. Assessment methodologies include predictive modeling and decision protocols that relate forest management practices to environmental quality and nonpoint source control strategies to total forest and watershed resource management including the socioeconomic aspects and assessment of trends. Pollution control or forest management methods include cost-effective structural (i.e., engineering technologies) and nonstructural (e.g., land use constraints) forest management practices designed to reduce pollutants generated primarily via runoff.

Integrated Pest Management --

The objective of the Integrated Pest Management area is to develop and demonstrate optimized pest control strategies based upon detailed biological knowledge of the interactions between combinations of non-chemical and chemical pest controls to reduce the pests and crops. This information is used to identify optimal environmental loading of undesirable chemicals. The program provides for the development and application of strategies and tactics of pest control for major pesticides-using crop ecosystems which will permit marked reduction in dependence on pesticide chemicals as a regular agricultural pest management practice. Major agronomic, fruit, and vegetable ecosystems are studied either simultaneously as interacting groups or individually where insect control is feasible using a variety of nonpesticide means. Such means may include insect and plant pathogens, e.g., viruses, bacteria and insect growth regulators (IGR) such as juvenile hormones and sex attractants. This work is a coordinated interagency program with the National Science Foundation, U.S. Department of Agriculture, and university community.

Examples of major near-term outputs of the Renewable Resources Industries Subprogram are listed below:

- Validate Agricultural Runoff Model for the Great Lakes and Piedmont Regions for both pesticides and nutrients, including improvement of transformation sub-models.

- Validate the Nonpoint Source Runoff Model under rural conditions of runoff, including improvement of the nutrient submodels.

- Completion of Vol. II of the manual, "Control of Water Pollution from Cropland" in cooperation with USDA for use by the local agricultural community in development of water pollution management guidelines.

- Completion of an interim economic evaluation of alternate implementation strategies for control of agricultural nonpoint sources of sediment and nutrients in the Corn Belt.

- Assess the cost-effectiveness of existing soil and water conservation practices designed to prevent and control environmental pollution from nonirrigated crop production.

- Completion of the first annual assessment of the environmental impact of trends in agriculture and forestry production.

- Demonstration of total salinity control program in Upper colorado River Basin.

- Evaluation and demonstration of tailwater management systems for salinity and sediment control in Pacific Northwest and West.

- Conference on implementation of improved management methods for irrigation return flows.

- Study on achieving irrigation return flow quality control through improved legal systems.

- Evaluation of runoff potential from animal manure applied to cropland at both optimum production levels and disposal rates.

- Comparison of animal waste application methodology and runoff control measures to enable the development of cost-effective management practices.

- Summary of management systems to control pollution from small farms, barnyards, and pastures.

- Development of a methodology for evaluating the cost-effectiveness of alternative forestry practices for controlling erosion.

- Development of models for design and operation of animal waste storage/retention structures and land application systems.

- Completion of comprehensive statement on research needs and alternate implementation plans for future R&D efforts in controlling environmental pollution from forestry activities.

- Development of a methodology for evaluating the cost-effectiveness of alternative forestry practices for controlling erosion.

- Development of pest management strategies and tactics for major crop ecosystems and demonstration of strategies on two major crops (annual report).

Current budget levels will permit research in the nonirrigated crop production category to produce assessment tools limited to the major crop production areas of the Nation. Emphasis will be directed toward development of pesticide and plant nutrient mathematical models with watershed and gross basin-wide assessment and prediction capability for the major crop production regions (i.e., Piedmont, Great Lakes, Corn Belt and Coastal Plain). In addition, cost-effective evaluation methods, based on the models, will be developed to select alternate implementation strategies for control of agricultural nonpoint sources of sediment and agricultural chemicals in the major crop production regions. Implementation strategies that incorporate individual and watershed management systems and assess both pollution potential and cost-effectiveness and economic aspects will be evaluated. Also, short and long-term trends in agricultural production which may adversely impact environmental quality will be assessed. Efforts will focus on systems of highest priority, such as conversion of marginal lands to cropland (limited to several states), chemical/energy intensive production practices, minimum tillage operations, and mega-farm concepts. The studies will include the socioeconomic aspects of the trends on a nationwide basis.

In the category of irrigated crop production, a large part of the effort will be devoted to the development of irrigation system management methods to reduce the level of pollutants in irrigation return flows (IRF). A prototype evaluation of the effects of irrigation management practices on IRF quality should lead to more reliable comparisons of irrigation practices in the field. Ongoing demonstrations of a total salinity control program in the Upper Rio Grande River Basin will add information to similar studies completed earlier, enabling development of salinity management manuals of recommended methods and practices. Additional manuals will be developed for total system management of salinity, sediment, nutrients and biocides control in IRF. Implementation of developed methods will be addressed through analysis of economic, legal and institutional constraints to adoption of technically feasible IRF control packages, by holding a conference on BMP methods for IRF pollution control, and by definition of BMP criteria by crops, soils, and climate.

Another aspect of the IRF program concerns the development and application of predictive methods for management of pollutants. In conjunction with the demonstration of the total salinity control program in the Upper Rio Grande River Basin mentioned above will be a demonstration of the field applicability of an IRF water quality model. Integrated total management models and appropriate manuals will be developed for control of salinity, nutrients, sediments, and biocides in IRF. Regional watershed management models will be completed with incorporate structural and non-structural management approaches for irrigated agriculture.

In the animal production area, land application of wastes from confined animal production will continue to be emphasized. Criteria for land applications, manure storage, and runoff control from application sites in northeastern U.S. will be developed and demonstrated. Grass filters will be evaluated for retention of animal waste runoff. Nitrogen and heavy metal movement into the soil and from land application sites will be studied. Manuals will be written on cost-effective waste application techniques and runoff control measures and on a model developed, evaluated, and verified for land application practices and scheduling.

The problem cause by the smaller feeding operations that do not come under the jurisdiction of the NPDES permit program will be evaluated. Characterization studies will be conducted on animal wastes throughout major feeding areas of the U.S. and on runoff from range and pasture operations in southeastern, eastern, and western U.S., for species including dairy, beef, swine, sheep, and turkey. Measures to control runoff of manure from pastures in humid and subhumid regions will be demonstrated. A series of manuals will be prepared for use by producers on management systems for unconfined animal production waste disposal in major problem areas.

To aid those concerned with the problem of manure and runoff disposal in areas where land application is not feasible or practical, a system using aquatic vegetation for renovation of animal waste lagoon water will be demonstrated. State laws, regulations, and other codes impacting the management of animal wastes e.g., land application restriction will be analyzed, as will alternate institutional arrangements. Increased attention will be given to the socioeconomic aspects of improved BMP's.

Research in forest management will continue development of guidelines and assessment tools and evaluating candidate forestry BMP's in cooperation with the U.S. Forest Service and timber industry to the fullest extent possible. An interagency agreement with the USFS will result in the development of a handbook for selection of non'point-source controls for forestry activities. A general resource planning model integrating pollutant loading models with forest management models will be developed. Software for a watershed-scale model to predict loading rates for specific pollutants for specific forest practices will also be developed.

Because of their dual role as user and producer of research, the U.S. Forest Service will continue to be encouraged and assisted with supplemental funding to conduct relevant research. ORD's program will be primarily extramural with implementation via interagency agreements as well as coordinated grants and contracts with State forestry colleges and universities.

The major effort in the integrated pest management area will continue under the aegis of an interagency research agreement with the National Science Foundation. Control strategies will be developed and then where appropriate, demonstrated. Projects will be initiated to disseminate technical pest control information and to implement crop ecosystem control strategies. As the main effort of this program declines, more responsibility for demonstration and implementation will be assumed by other Federal and state agencies.

While present emphasis is on insect pest control, a gradual shift of effort will be toward pest-plant control during the years FY 79-80. A lessor effort will be devoted to development of a scientific basis for nonchemical control strategies for urban pests, such as cockroaches, ants and shade tree pests. Strategies and tactics for major crop ecosystems (e.g., soybean and citrus) will continue to be developed and demonstrated. A vector ecological study will be demonstrated and a pest ecosystem model will be implemented as a control system.

Potential Subprogram Growth Areas --

Because of fiscal constraints, the program is not operating at an optimal level. If a modest growth of the program were authorized, several priority areas could be expanded and accelerated. The animal production area would involve development of a manual for utilization of wastes from various land-premium areas of the U.S., studies of disposal of manure from animals fed agricultural wastes and, determination of effects of housing and on characteristics of manure for reuse/recycle/by-product recovery processes.

In the forest management area this would allow completion of the following: development of a data base in several geographic regions to calibrate and test watershed models for selected pollutants and preparation of user manuals displaying models and loading functions for classes for forest practices under different forest types and other critical variables.

In the integrated pest management category, funds would be used to accelerate demonstration/implementation of a pest ecosystem model into pest control system for a particular crop; insect pheromone and juvenile hormone control systems will be developed and demonstrated; and pathogenic controls for pest will be investigated and developed.

Increased emphasis in the nonirrigated crop production area would be directed to several areas. First, the predictive and assessment pesticide and nutrient models would be expanded to include major pollutants such as biodegradable organics, metals and coliforms; improvement of accuracy by refinement of transformation submodels; and, verification in high priority crop production regions not listed in the base program. It would also be possible to demonstrate and evaluate best management practices in major crop production regions on a watershed scale. An important area would be the provision of "hands-on" real-time tools for the individual farmer/producer to select appropriate management systems to minimize environmental pollution impact. Long-term trend assessments would be extended to areas such as sub-marginal and steep slope land in all significant production areas in the Nation; and the use of remote sensing to predict/reveal trends and to evaluate pollution potential; the potential environmental impact of use of non-food crop production for energy bio-conversion; the evaluation of tradeoff of pollution reduction controls versus change in other crops; and the environmental and economic impact of growth of corporate farms. These long-term trend studies would require close coordination with the USDA, including EPA assistance in supplemental funding for conducting relevant research.

In the irrigated crop production area efforts would be expended to initiate development of total system management manuals for pollutants in IRF at an earlier date; initiate development of regional strategy models to impact planning for irrigated agriculture at an earlier date; evaluate pollution potential of supplemental irrigation in semihumid agricultural regions; and evaluate total management system concepts for control of salinity, nutrients, sediments, and biocides in arid and semiarid regions.

Additional resources in the animal production area will result in the following: study of pathogen transmission from animal wastes by land application or runoff pathways; evaluation of winter manure storage and subsequent land application techniques in cold northern states; initiation of study of housing and feeding effects on manure characteristics at an earlier date; production of species manuals for use by producers at an earlier date; and, unconfined range and pasture studies.

In the forest management category modest program growth would allow for increased participation by EPA in developing and testing planning tools and assessing the implementability of new and improved forestry best management practices. Sufficient data would be generated to test planning tools and alternative management practices under different situations. Completion dates of outputs under the level budget would be accelerated generally by one year. A sufficient cost and effectiveness data base would be developed to allow quantitative analysis of alternative forest management practices and testing of methodologies. New and improved forestry BMP's and assessment tools that allow for evaluation of economic and social impacts of implementation could be tested.

The institutional aspects and/or constraints of implementing forestry BMP's for land under both public and private ownership would be investigated. The applicability of economic incentives and other methods for implementing forest management pollution control would be evaluated. A methodology and user manual for estimating the economic and social costs and impacts of implementing forest nonpoint source pollution controls at the firm, regional and national levels would be developed. Pollutant transport, water quality and economic models would be integrated and a watershed management model accounting for agricultural and forest sources would be developed and tested. User manuals for design, implementation and evaluation of cost-effective areawide agricultural and forest pollution management systems would be developed and tested. A multimedia (air and water) pollution control model for forest resource management could be developed and verified.

In the integrated pest management program, demonstrations of crop ecosystems pest control and implementation of additional pest ecosystem models into viable control systems could be accelerated.

Minerals, Processing, and Manufacturing Industries Subprogram

Industrial pollution is the source of half of the biochemical oxygen demand (BOD) of the Nation's lakes, rivers and streams. Industry also produces most of the water pollution load of refractory, hazardous and toxic materials, including heavy metals, organics and dissolved solids. Similarly, even with control levels required under New Source Performance Standards (NSPS), half the emissions or particulates and a significant fraction of the emissions of sulfur oxides and most hazardous pollutants into the atmosphere come from industrial sources. Residues from industrial processes have a significant impact due to their volume (approximately three times municipal) and nature consisting primarily of sludges laden with toxic metals and halogenated organic waste materials.

To address these industrial environmental pollution problems, a research, development and demonstration (RD&D) program to identify, prevent, control and manage pollution from industrial activities has been established. The Minerals, Processing, and Manufacturing Industries Subprogram includes sources of water, air and residue pollution from industrial activities--mining, manufacturing, processing, service and trade industries. The activities involved range from extraction to production of raw materials and processing of materials into intermediate and consumer products. This research covers all or part of thirty major groupings identified in the Standard Industrial Classification Manual (SIC).

Industrial pollution problems cannot be effectively controlled by addressing only a single medium (i.e., air, water or land). A more effective approach is to deal with pollution as problems whose solutions may impact all media. A systems approach that takes air, water and land into account to treat pollution problems avoids transferring pollutional impacts from one medium to another, e.g., treatment of liquid effluents in a way that produces no secondary air pollution or land disposal problems.

To emphasize a coordinated, multimedia approach to industrial pollution problems, research activities are organized along industrial lines. Responsibility for total environmental protection is assigned to each industrial component. Four research categories -- Material Production, Materials Processing, Combined Sources, and Hazardous Materials Incidents-- comprise the Minerals, Processing, and Manufacturing Subprogram.

Materials Production --

Materials Production includes problems of industries concerned with exploration for and exploitation and production of raw materials. This category specifically is comprised of the following areas: iron and steel; non-ferrous metals; petroleum refining; and general mining. Not included in this category is extraction of nonrenewable resources used primarily as a source of energy, such as coal, or renewable resources, such as agricultural products.

Material Processing --

Material Processing covers many industrial activities that mechanically or chemically change a material from one form to another. This category encompasses nine areas: Metal finishing (including electroplating, machinery and fabricated metal products, and transportation equipment); petrochemicals; inorganic chemicals; agricultural chemicals, to (including fertilizers and pesticides); textiles; miscellaneous industries, such as printing and photographic, stone, glass, clay, laundries, etc.; pulp, paper, and wood; food products; and organic and specialty chemicals.

Combined Sources --

Combined Sources covers the development of technology to treat industrial wastes from several plants within a region with a single facility or in combination with municipal waste management.

Hazardous Materials Incidents --

Hazardous Materials Incidents involves development of methods to treat accidental spills of hazardous materials as required in the Federal Water Pollution Control Act.

A goal of the Minerals Processing, and Manufacturing Industries research subprogram is to serve as a catalyst to promote cooperation and coordination between Federal agencies, States and technology users to achieve levels of pollutant control mandated by EPA's legislative authorities. Research objectives are planned to meet the timing for reduction or elimination of pollutant discharge required by Agency regulations. Pollution abatement goals will be helped by this program through RD&D on a wide spectrum of industrial activities, culminating in the reduction to practice of cost-effective pollution control technologies.

Industrial organizations will continue to be responsible for most development and demonstration efforts required to meet pollution abatement goals. Solutions to industrial pollution problems may include commercially-available treatment technology or adaptions of control technology in use on other processes. Pollution problems may also be prevented or controlled by modifications in process design or operation--solutions that may be specific to a single plant and wholly under purview of the plant operator. In certain cases, however, federally financed, independent RD&D must be conducted to ensure that national pollution abatement goals will be met.

The promulgation of new standards and regulations to control or prevent discharge of toxic and hazardous pollutants from industrial sources will produce new research requirements. Protection measures required under such standards may be significantly different from those commonly used in industrial pollution abatement, and may require intensive cooperative efforts to demonstrate and evaluate new as well as currently available technology.

There are 600 industrial categories as defined by EPA regulations, each with four levels of control to be achieved within a 10-year span. Effluent guidelines have been established by EPA for a large number of these categories, and more guidelines will be promulgated in the future.

Several regulatory paths are available for devising strategies to ensure that mandates of the Clean Air Act are met. Industrial technology research supports each of these regulatory approaches. Ambient air quality standards (AAQS) have been established for six pollutants, known as criteria pollutants. The States have submitted implementation plans that provide for attainment of the AAQS. Many areas will not attain the AAQS because they lack available control technology, control is too costly, or fuel supplies are limited. The likelihood is that existing technology will not permit the standards to be maintained in the future because of anticipated growth of industrial capacity and consequently, of emissions. The goal of the Minerals, Processing, and Manufacturing Subprogram is to provide technically and economically feasible processes that allow attainment and maintenance of AAQS.

New Source Performance Standards (NSPS) for the six criteria pollutants have been established for 12 industries and proposed for eight others. The expectation is that another 25 criteria pollutants will be promulgated between 1976 and 1978 for other industrial categories. The need for an expanded technology RD&D program to support these and future standards is critical.

EPA has already established or is in the process of setting emission standards for certain other hazardous (noncriteria) pollutants such as mercury, fluorides, asbestos, vinyl chloride, chloromethyl ether and hexachlorobenzene. Because of inadequate understanding of effects of industrial chemicals and materials in the environment, it is likely that industrial chemicals and materials in the environment, it is likely that more new environmental pollutants will be discovered in the future.

Experience in dealing with hazardous materials (e.g., asbestos and vinyl chloride) indicates that there are usually insufficient health effects data to establish a "safe" exposure level. EPA must therefore rely on a technology-based standard to ensure that exposures do not present substantial risks to people. Anticipatory RD&D on control of emissions of potentially hazardous materials can serve the Nation well by providing assessments for the feasibility of control of such materials.

Finally, the Agency has recently promulgated a list of hazardous materials which will serve as a basis for recovery for damages resulting from spill of such materials. The capability to contain and clean up spills of so many materials is just beginning to emerge from the hazardous spills RD&D activity.

To date, this technology RD&D program has provided the technical basis for an estimated 100 industrial categories at the Best Pratical Technology (1977) and Best Available Treatment (1983) levels of control. Additional technology gaps and associated RD&D needs, if any, for specified Best Practical Technology levels may be identified as a result of adjudicatory hearings. There are, however, RD&D requirements for Best Available Technology, New Source Performance Standards, Pretreatment Standards, and Toxic Standards as defined in the 1972 Federal Water Pollution Control Act Amendments. With the passage of the Resource Conservation and Recovery Act of 1976, a further increase in supportive activities will occur.

The data base from which decisions can be made for industrial air pollution control is generally weak.. Consequently, a sizeable assessment program has been initiated to determine what sources may require control technology RD&D in the future. A complicating factor is the large number of industrial sources that can be addressed. To provide priorities for air pollution control efforts, available emissions data (calculated, measured, or otherwise estimated) were used to calculate a relative ranking of 600 industries. The ranking took into account the specific pollutants emitted, the relative toxicity of the pollutant, the physical configuration of the emitting source and the population in close proximity to the source. As a result, more detailed assessments have been started for the 40 highest priority industries. New industries will be added to the study list as ongoing assessments are completed--subject to availability of funds.

In FY 1978, activities will continue to be focused on the problem of toxic and hazardous emissions and discharges. As source assessment are completed, available control technology, together with economic implications will be identified. This information will continue to serve as a basis for updating effluent guidelines and for regulating the use and disposal of toxic chemicals.

Complete source assessments will establish detailed chemical characterizations of industrial waste streams. These assessments will relate effluent composition to production variables including alternative processes, types of raw materials, operating conditons and waste streams, but also will provide data on the costs of alternatives for reducing adverse environmental impacts.

Major near-term outputs to be achieved include:

- Complete assessment of the occurrence of the 65 pollutants in the 21 industries specified in the court decree (NRDC vs. Train, 8 ERC 2120)
- Complete assessment of the applicability of currently available control technology in being able to remove toxic and hazardous pollutants
- Complete assessment of state-of-the-art of control procedures for non-energy mining activities
- Demonstration of field detection and identification kit for spilled hazardous materials
- Complete source assessments for toxic and hazardous air emissions from selected critical industries
- Preliminary assessment of applicability of known control technology to remove these pollutants
- Development of rapid screening tests to determine toxicity of airborne emissions.

To significantly enhance protection of the environment from industrial pollution sources by the mid 1980's, the Minerals, Processing, and Manufactring Subprogram is recognized as a high priority RD&D area. Because of the time restraints in the legislation and anticipated timing of additional New Source Performance and Hazardous Materials Standards and new Toxic Substances Standards, a major effort in R&D is necessary if industry is to meet these regulations and standards in a timely fashion. Resource requirements beyond FY 1981 can be substantially reduced as efforts change from a developmental to a technology application mode.

Since the recent passage of the Toxic Substances Control Act and the amendments to the Solid Waste Disposal Act, together with the settlement agreement (NRDC et al vs Train, 8 ERC 2120), the latter of which requires EPA to develop and promulgate regulations for 65 classes of pollutant chemicals in 21 industrial categories which will require application of BATEA, the planned R&D effort has been modified significantly to specifically address suspected hazardous chemicals. Control technology options are required as a parallel effort to the health and ecological efforts R&D program. In some cases, technology for the control of hazardous materials may already exist. In many cases, however, the technology may be inadequate. Generally, the capabilities of advanced treatment options are unproven for specific industrial waste streams. Hence, there exists a need for categorization of hazardous substances in industrial effluents by source, and development of control technology that can control broad categories of effluents to air, water and land. This development phase of the hazardous substances program involves four steps:

- Effluent characterization and control option evaluation
- Laboratory scale studies of specific control options
- Pilot scale follow-on studies
- Demonstration scale activities

The control technology options to be considered should fall into one of three classes:

Effluent Control Technology --
This class includes all forms of add-on, collection, and/or conversion processes and devices to prevent pollutant release to the environment.

Process Modification --
Such modifications include all changes to manufacturing operations (including feedstock changes) and producer use to obviate the release of hazardous substances.

Substitution --
This approach includes the use of alternative products as substitutes for more environmentally objectionable products of polluting processes.

For each hazardous substance or class thereof, information will be gathered from source characterization and other pertinent studies. This data will facilitate preliminary parameteric analysis of control technology options taking into account the following factors:

- Efficiency
- Power consumption
- Space requirements
- Siting
- Resource requirements (capital and operating)
- Retofit capability

- Materials of construction
- Failure analysis
- Secondary environmental impacts
- Timing for implementation

Inasmuch as substitution of feed materials, processes, or products will be considered a control option, technical data will be gathered or generated to characterize substitute processes or products and to assess their feasibility. The analysis will include modifications in process hardware necessary to produce the substitute product. The outputs will be technical evaluations, cost data, and preliminary assessments of the substitute control alternatives.

Economic parametric analysis options for controlling hazardous substances may include the following factors:

- For various control processes, develop effectiveness versus cost curves to encompass the range of treatment alternatives.
- Determine the cost of alternative process modifications. In certain industrial plants, the most economical solution may be waste stream elimination or reduction by process modification.
- Determine the energy requirements for each control option.
- Determine the availability of other resources required for treatment systems. If a process requires a nonrenewable product of limited supply, this consideration could seriously limit its utility.
- Assess the overall economic feasibility of the option.

It is anticipated that the parameteric analysis of three overall control options (effluent control technology, process modification, and substitution) will lead to identification of generic control approaches applicable to classes of hazardous substance pollutants. The following examples illustrate potential options that may arise through the control-option parameteric analysis.

The reductive degradation process developed by EPA-ORD for chlorocarbon pesticide cleanup may have generic applicability for cleanup of industrial process wastewaters containing chlorinated hydrocarbon pollutants. These pollutants may occur in effluents from pulp bleaching, pesticides, plastics, textiles, organic chemicals, and other industrial operations. Results to date have shown the process to have potential for application to treatment of wastewaters from the production of the cyclodiene pesticides, aldrin/dieldrin, endrin, heptachlor, and chlordane; DDT and related metabolites; the chlorinated camphene, toxaphene; the chlorinated cyclohexane, lindane; the chlorinated phenoxyalkanoic acid herbicides, 2,4-D and 2,4,5-T; the cyclodecanoe, kepone; and the industrial heat transfer medium in transformers and capacitors, PCBs. Further, and quite possibly the most important application, would be in the water supply treatment area.

Closed cycle processing as a technique to eliminate effluents from pulp and paper, textile fiber, and petrochemical operations will be analyzed for generic applicability potential. EPA demonstration projects in primary fiber mills and petrochemical manufacturing facilities have proven feasible and effective.

Ozone substitution for chlorine as a treatment agent in municipal waste operations shows genuine promise. Generic applicability of alternate oxidizing agents in place of chlorine to industrial and other waste stream treatment operations may lead to technology changes affecting reduced hazardous substance effluents.

It has become apparent that research must be shifted from the traditional end-of-pipe treatment for parameters such as BOD and suspended solids to the control of hazardous substances contained in the effluents. To accomplish this change, a major assessment program has been initiated to determine the nature and quantities of these pollutants. Emphasis initially is being placed on certain of the 21 industries and 65 pollutants identified in the toxic effluents consent decree. In addition, work on ongoing projects in all industrial areas has been modified to provide the maximum attainable data on the discharge and treatability of hazardous pollutants from the industrial facility involved.

Resource allocations have been shifted away from those industrial categories where there is little probability of hazardous pollutant discharge toward those areas where there is obvious higher probability of sizable discharges. For example, the R&D program in the food industry, where BOD and suspended solids are dominant concerns, has been significantly reduced and the resources shifted into such industries as organic chemicals manufacture where there are known hazardous materials.

Potential Subprogram Growth Areas --

The Minerals, Processing and Manufacturing Subprogram is currently funded below the optimal level due to general Federal fiscal constraints. If this funding level continues, the program emphasis will remain unchanged, but the outputs required to allow the Agency to meet its mandates will be delayed--in some instances beyond the point where the promulgation of regulations is required. For example, it will not be possible to complete the assessment of the occurrence of hazardous pollutants from all 21 industries required in a timely fashion. In addition, the development of equipment and techniques required to allow response to spills of hazardous materials will be delayed for several years.

If modest growth were to be authorized, the above delays would be alleviated, and projects allowing for a larger number of alternatives in hazardous discharge control could be conducted. For example, the program could focus on changes in manufacturing processes to eliminate hazardous discharges, including production process change and feedstock substitutions. Selection of industrial areas to be included in this program will be based on the environmental assessments currently underway. The following specific products would be possible under modest growth through the five-year period:

- Assessment of industrial categories to determine those areas where process modifications and/or raw material substitutions are feasible

- Assessment of economic impact of these changes in relation to possible utilization of end-of-pipe control technology to reduce or eliminate discharge of hazardous materials

- Initiation of programs in selected areas to prove economic feasibility of process modification and/or materials substitutions as an adequate pollution control technique

ENERGY/ENVIRONMENT PROGRAM

As the Nation strives to reduce its foreign energy dependence, energy-related environmental problems arising from domestic energy development become increasingly important. A major mission for the Agency is the protection of public health and welfare from the adverse effects of energy systems. Research and development efforts toward this end are mandated by the Clean Air Act, the Federal Water Pollution Control Act, and the Resources Recovery Act. Such protection must be accomplished through a multimedia approach so that the control of one form of pollution does not result in other unacceptable impacts. Environmental protection must be accomplished in a reasonable manner and at acceptable cost compatible with other national interests.

As the Nation attempts to solve its serious energy needs and problems, several approaches have been proposed:

- Increased use of coal through direct burning
- Replacement of dwindling oil and gas supplies with synthetic gas and liquid fuels derived from coal
- Use of alternate sources of energy such as solid waste, solar energy, geothermal steam and brine, and nuclear fission, and
- More efficient energy extraction (mining, secondary recovery) and utilization (combustion) processes.

Because of the potentially acute health and ecological effects associated with these energy initiatives and with both existing and new technologies for fuel processing, and utilization, the EPA has made a major commitment to ensuring that the environment and human health are protected. Further, since many of the problems are long-term (e.g., many technologies will not be available and in commercial use before early 1985), EPA must have programs underway now to develop the health and technical data base necessary to support environmental quality standards and source discharge or emission regulations for energy pollutants. The lead times for health assessment and control technology development are such that research programs must be implemented now if energy development is to be compatible with environmental protection.

Several long-term problem areas are anticipated for the regulatory and enforcement components of the Agency. The increased reliance on substitute fuels from coal and oil shale, requiring cleaning, gasification, liquefaction, and other processing techniques can generate new pollutants whose effects are not known and must be defined. For example, coal gasification processes may emit unacceptable quantities of carcinogenic materials. Another problem area concerns the potentially cumulative chronic health and ecological effects of new and emerging energy sources, such as advanced combustion systems and geothermal facilities.

The Agency must also address many energy/environment related problems in the near-term. The unavailability of domestic oil and increased dependence upon foreign oil supply may result in converting a number of oil-fired boilers to coal. Significant conversion from oil to coal will result in the additional emission of particulates, nitrogen oxides, sulfur compounds, and other combustion pollutants. The increased use of coal and oil shale will accelerate mining, in semi-arid western areas, raising serious questions about restoration of mined lands and degradation of the quality of available ground and surface water resources. The expanded interests in offshore oil may lead to increasing the severity of the environmental problems associated with petroleum extraction, transportation and coastal refining facilities.

The primary goals of the Energy Research and Development (R&D) program are to provide a sound data base necessary for the Agency to establish regulations and incentives to encourage the use of environmentally acceptable practices in extraction, processing, and utilization of energy resources, and to provide environmental control options, as soon as practicable, for those extraction, processing and utilization practices which cause significant health and ecological damage.

The approach for addressing the near-term pollution problems involves reducing the air, water and other pollution associated with expanded coal use. Principally, this will entail completing reliability testing and sludge disposal research and development on current generation stack gas scrubbers and demonstrating improved, less expensive scrubbers which produce more easily disposable by-products. In addition, assessment activities will determine the potential environmental problems associated with presently unregulated coal combustion pollutants, e.g. trace elements, organics, sulfates, etc. Also, the scientific data base on health and ecological effects of coal and oil-shale extraction, and on environmentally acceptable mining and reclamation techniques will be developed.

The definition of the environmental problems and requirements for control of the longer-term energy problems is of particular importance. EPA does not have the responsibility for the energy technology development, but must work in concert with the Energy Research and Development Administration (ERDA) and other agencies. The approach utilized has the following elements: conduct environmental assessments of emerging energy extraction, processing and utilization techniques to identify new pollutants and determine their potential health and ecological effects; develop adequate scientific basis for development of new environmental regulations; provide guidance on control technology requirements to Federal and industry groups developing new technologies; assist in the development (ORD) has special expertise; and assess the adequacy of control technologies.

The overall Interagency Energy/Environment Program is structured to implement the 1974 recommendations of the two Council on Environmental Quality (CEQ)/Office of Management and Budget (OMB) energy task force reports.

The implementation approach used to maximize the useful output of the program involves an extramural approach, with EPA relying heavily on expertise available within both the Federal and industrial sectors. In fact, EPA manages, coordinates and integrates the efforts of 16 Federal agencies under the auspices of the Interagency Energy/Environment Program.

In addition to the major interagency components of the program, much of the Research, Development and Demonstration (R,D&D) Program is performed by industrial concerns and universities via contracts and grants. Each of the participating agencies or departments has its own charges, e.g., management of the Federally owned energy resources, management of Federal lands, the development of new fuel sources or cycles, etc. In pursuing its own programs and responsibilities, each agency must have access to the available information on the environmental effects of energy development and must also perform the research necessary to provide additional needed data. The EPA management of an interagency program attempts to minimize the overlap of the separate research programs and to assure a comprehensive coverage of all energy environment questions. In addition, the results of the multi-agency research program are disseminated and reviewed through a system of publications and joint conferences and symposia supported by the Office of Energy, Minerals and Industry (OEMI-EPA) management function.

Energy Health and Ecological Effects Subprogram

The energy-related interagency environmental processes and effects program is designed to determine the environmental effects of each energy source's fuel cycle (extraction, processing, conversion, utilization and multi-component). The program has the overall objective of presenting the clearest possible statement of the nature and extent of actual and potential changes in the human environment associated with ongoing and proposed energy development. To do this successfully, the program includes laboratory characterization of the nature and effects of energy-related pollutants and field studies to record the baseline and ecosystem responses to actual energy projects. The ultimate goal of the program is to compile and assess fundamental data so that, as energy production increases, measures can be taken early enough to protect both the ecosystem and human health, welfare, and social goals.

The criteria for determining research priorities are as follows:

- Potential magnitude and importance of human health and environmental effects;
- Nature and potential magnitude of the developing technology;
- Expected rate of development of the technology.

For the short term, primary efforts reflect EPA regulatory requirements: A sound technical base must be provided to support the establishment of standards and regulations and to assure a strong Agency defense in event of litigation.

In the intermediate term, research is directed to problem identication and assessment. Early knowledge of adverse energy system health and ecological effects are required prior to system implementation to avoid the need for costly retrofit controls. This work leads to setting priorities for later work and where possible, to avoidance of environmental insults.

The long-term research is largely based on a strategy to prevent environmental damage rather than to only regulate it. For that reason, research is undertaken to better understand environmental processes and effects. Avoidance of all yet unrecognized hazards is the major ultimate objective.

The energy-related processes and effects research is divided into four closely related functional areas: pollutant characterization, measurement and monitoring; environmental transport processes; health effects and ecological effects.

Pollutant Characterization, Measurment and Monitoring --

The measurement and monitoring functional area is directed toward identifying and quantifying pollutants related to energy production or use, as well as improvement of pollutant measurement capabilities. The two main objectives in this area are to accelerate development of new and improved sampling and analysis methods for energy-related pollutants and to identify, measure and monitor pollutants associated with rapid implementation of emerging energy technologies.

The objective of the current monitoring studies is to establish a valid ambient environmental baseline in the most environmentally vulnerable areas projected for major energy development over the next decade. The Western Energy/Environment Monitoring Study has been initiated to provide a multi-media baseline in those areas of the Northern Great Plains and Central and Southern Rocky Mountain States where accelerated land leasing for strip mining of coal and construction of large coal-fired power plants is planned. Also, potential oil shale and geothermal development areas are receiving attention as national plans for their development evolve. Emphasis has been placed on the quality of the data and reference to measurement standards. Additional smaller studies related to coal mining pollution are underway in the Midwestern Interior and Pacific Northwest Coastal Province.

Monitoring techniques development includes projects aimed at producing automated systems for interpreting synoptic land use information; at groundwater monitoring methodology for specific energy resource types; and at a system for quantifying visibility measurements.

An additional major effort within the measurement and monitoring functional area is the development of analytical measurement methods and instrumentation for air and water pollutants associated with energy extraction and conversion. Present efforts are focused on inorganic compounds from conventional operations, such as sulfate aerosol measurement and specific trace element analysis. Current efforts also include the problem of measuring low level trace inorganics and compounds in water associated with second generation energy technologies.

Environmental Transport Processes --

This functional area refers to the transmission of energy-related pollutants by air, water and soil systems from their sources to their destination (fate) in man and the environment. Additionally, it covers any physical and chemical changes in the pollutants occurring during transport.

The atmospheric portion is designed to determine transport and fate of airborne pollutants generated from various energy activities. Technologies to be considered include oil shale, coal combustion, coal extraction and is coal gasification and liquefaction. The major emphasis is on determination of chemical and physical processes associated with conversion of sulfur and nitrogen oxides to sulfates and nitrates, photochemical oxidant transport and, effects on visibility reduction, haze and radiation balance of airborne aerosols generated by energy-related activities.

The freshwater portion focuses on surface and groundwaters. It is designed to trace the environmental pathways and ultimate fate of organic and inorganic pollutants, complex effluents, dissolved and suspended solids and thermal discharges generated by coal and oil shale development and coal gasification and liquefaction. The marine portion is similarly structured, but concentrates on pollutants from such technologies as offshore power generation, petroleum exploration and extraction and construction of deep-water ports.

Health Effects --

The energy related health effects functional area is designed to provide the health data base necessary to assess the impact of enhanced energy production and utilization on a schedule consistent with energy technology development and commercialization.

The objectives of the program are to determine the qualitative and quantitative effects of energy related agents upon human health, to ascertain the risks to individuals in various population groups arising from all aspects of energy production for each of the diverse energy cycles and to provide information on health costs and protective measures which can be used for the establishment of guidance and regulatory actions.

The components of the program include identification of hazardous agents associated with energy technologies, development of more sensitive and rapid methods to evaluate the dose and damage to man, determination of the metabolism and fate of hazardous agents associated with energy technologies, determination of the damage, repair, recovery, protection, and amelioration for biological systems exposed to hazardous agents, and evaluation of short-term and long-term hazards of exposure of normal, susceptible and stressed population groups to differing levels and combinations of pollutants through clinical epidemiological and toxicological studies.

Ecological Effects --

Ecological effects research studies are oriented to both specific pollutants and broader energy technologies. These studies are designed to determine not only organism impacts but also the total ecosystem effects of energy development activities. The research objectives are designed to determine effects of organic pollutants, inorganic pollutants, thermal discharges, complex effluents, dissolved solids and suspended solids on freshwater, marine and terrestrial ecosystems. Near-term energy technologies related to oil shale production, coal extraction, gasification and liquefaction will receive initial emphasis.

Acute and chronic toxicological effects on freshwater organisms will be determined. The marine ecosystem studies will seek to establish background levels of relevant contaminants in marine organisms and habitats. Further marine studies will include the effects of petroleum extraction and conversion operations, construction of deep-water ports and effluents from offshore nuclear facilities on marine and estuarine organisms and ecosystems.

The terrestrial effects studies will determine the acute and chronic dose-response relationships from stress of air pollutants from coal and oil shale extraction, conversion and utilization processes. Additional terrestrial effects projects will focus on revegetation and reclamation of surface-mined areas in the arid West.

Assuming continued program funding at the current level, the following products would be available in the near term:

- Continue Western air, water and land use baseline monitoring studies and evaluate the need to intensify fine particulate and sulfate measurements, specific waterborne toxic measurements, and full scale automated multi-spectral analysis surveys.
- Preliminary report evaluating groundwater monitoring methodology requirements for Western strip mines, oil shale and geothermal developments.
- Evaluate air and water pollutant measurement and instrumentation development to determine if and when emphasis should be shifted from toxic elements and compounds to hazardous organics.
- Development of energy-related standard reference materials for calibration of ambient air and water measurement.

- Comprehensive initial estimate of low level trace contaminants in water from second generation fossil fuel technologies and identfication of gaps in measurement and monitoring methodology.

- Evaluation of existing groundwater models needed to predict changes in water flow and quality caused by mining operations.

- Determine transport and fate (a limited set) of energy-related pollutants in fresh surface water.

- Determine transport and fate of pollutants released by pipeline spills in the Arctic environment.

- Determine atmospheric transport and dilution of pollutants, chiefly sulfur dioxide from large single sources in the 100 km range.

- Determine transformation during transport of sulfur dioxide and nitrogen oxides coal-fired power plants in the 1000 km range.

- Develop and utilize measurement techniques for indicating sublethal repairable damage which can be used in conjunction with human studies (clinical-epidemiologically).

- Develop procedures and tools to determine environmental pollutant burdens in biological tissues (human and non-human).

- Develop procedures and techniques to reduce uncertainties in estimates of health impact which are dependent upon extrapolation of data obtained through animal experimentation.

- Chemical and biological field site studies of effects on aquatic ecosystems from coal extraction at a Colorado site.

- Establish necessary data base of information for use in evaluating the potential effects of coal-fired power plants on freshwater resources and ecosystems.

- Evaluate effects of crude oil on freshwater organisms in Arctic Lakes.

- Establish water quality limits and gudelines for water bodies in strip mined areas in Northern Great Plains, based on existing information only.

- Determine acute and chronic toxicity of petroleum products and biocides to marine and estuarine organisms.

Outputs delivered later in the five-year period would include the following:

- Establishment of a geographically broad multimedia baseline for regions of the Western U.S. projected for energy development. This baseline will be a reference for future trend monitoring and subsequent energy-related policy decisions on significant deterioration; on water resources use and water quality management; and on land use and strip mine reclamation.

- Development of a groundwater monitoring methodology for pollutants from coal mining, oil shale and geothermal development.

- Development of methodology for analysis and real-time measurement of sulfate aerosol.

- Development of measurement methods for energy-related trace elements and inorganic compounds (e.g., cyanides, toxic metals in acid mine drainage).

- Development of an automated synoptic monitoring system for rapid, cost-effective interpretation of strip mining and other energy-related data.

- Development of long-path, real-time measurement capability for major energy-related gaseous pollutants and particulates.

- Determine atmospheric chemistry of emissions from second generation energy technologies.

- Determine atmospheric transport and transformation of sulfur and nitrogen oxides to sulfates and nitrates in plumes from the complete size range of coal-fired power plants.

- Determine atmospheric effects, including visibility reduction and haze and radiation balance, caused by airborne aerosols produced by energy-related activities and develop methods of relating atmospheric visibility reduction to chemical and physical properties of fine particulates.

- Determine mass balance of pollutants in the air envelope of fuel conversion systems such as coal liquefaction and gasification.

- Determine biological, physical and chemical pathways and transfer mechanisms of energy-derived pollutants in soils, crops and animals.

- Determine in marine and estuarine water the origins, loads, transport pathways, transfer rates and fates of pollutants arising from offshore oil production.

- Evaluate validity of health data base for energy related criteria pollutants.

- Complete Phase I bioassay screening of available new energy technology facilties.

- Initiate retrospective and prospective epidemiological studies (occupational and general public population groups) associated with specific types of energy facilities.

- Develop and initiate screening system, dependent upon behavioral response indices for clinical and epidemiological studies.

- Complete animal carcinogenicity studies for several selected energy related pollutants.

- Complete costressor animal inhalation studies of polycyclic hydrocarbons at low levels of exposure.

- Develop improved techniques for estimating risk by extrapolation of animal data.

- Complete clinical studies on low level exposure to multiple stresses of energy related criteria pollutants.

- Evaluation of first phase research results on activities in petroleum hydrocarbon, trace metals, thermal effects and power plant effluents, with regard to physical, chemical and biological data for model development.

- An integrated, total media study of overall environmental impacts of strip mining and power plant development in Colstrip, Montana.

- Demonstrate reclamation/revegetation techniques for strip mined areas in the West.

- Determine marine and estuarine ecosystem impacts of coastal and offshore energy development activities.

Potential Subprogram Growth Areas --

Emphasis in the existing measurement and monitoring program has been on development of the instrumentation to measure sulfates in the atmosphere and toxic metals in water. In keeping pace with the emerging synthetic fuel industry an additional emphasis is required to develop rapid, accurate field monitoring and laboratory analytical methods for the measurement of hazardous organic materials in both air and water. Standardized monitoring equipment must be developed before these technologies reach commercialization.

In the future, in addition to the Western area studies of projected coal gasification plants, increments in the monitoring area will focus on limited regions in the Midwest and East where second generation coal conversion technologies (coal gasification and liquefaction) and associated coal mining are projected. Similarly, the devlopment of comprehensive multimedia monitoring guidelines will be developed to provide a consistent basis for ambient measurements by Federal, State and private entities.

These new studies will differ significantly from current studies in that they will be aimed at the measurement of ambient levels of organic emissions from the second generation technologies, in addition to the measurement of inorganic emissions such as sulfur oxides, nitric oxides and various compounds associated with airborne particulate matter. Emphasis will be placed on those ambient organics which are potentially carcinogenic.

Because the development of measurement instrumentation and methods leads the capability to establish an ambient monitoring program, outyear increments of this effort within the measurement and monitoring functional area will be focused on carcinogens from second generation energy technologies, such as coal gasification and liquefaction and oil shale development.

The development of new energy technologies, specifically coal gasification and liquefaction, will generate pollutants whose effects on both the occupational community and general population are as yet unknown. To be able to adequately assess health impacts of these emerging technologies in a time frame commensurate with anticipated development, emphasis must be placed on speeding the generation and utilization of diagnostic tools which can indicate early sublethal changes in behavior. Emphasis in this area hazardous organics associated with the synthetic fuel industry. Procedures and techniques would be developed to assess pollutant hazards based on their concentration and distribution, reaction in experimental organisms and the extrapolation of animal test data to man. Finally, an additional emphasis in clinical, epidemiological and animal toxicology would be incorporated to determine the effects of multiple pollutant stressors.

Additional efforts would be initiated to identify and quantify the major organic components of airborne particulate matter. These studies would be applicable to general urban industrial aerosols and would focus on particulate emissions from new technologies such as coal gasification and liquefaction, emphasizing key precursor conditions for transformation of organic aerosol fractions into potentially carcinogenic compounds, and the transport and spatial distribution of these compounds. The studies would also indentify and quantify the major sources of airborne particulate matter in representative atmospheres and attempt to project the incremental contribution of the new synthetic fuel technologies.

Energy Extraction and Processing Technology Subprogram

Overall objectives of this subprogram are to permit a rapid increase in extraction and processing of domestic energy resources and to enable these energy sources to be used effectively in an environmentally compatible manner. The research is divided into two areas: energy resource extraction and fuel processing.

Resource Extraction --

Resource Extraction R&D will assess potential environmental problems and control methods for underground and surface and coal mining, oil shale extraction and exploration for and recovery of domestic inland and offshore oil and gas. All these extraction processes have the potential to severely damage water and land quality. For that reason, the chief goal of this research is to provide enough data and analysis to ensure that commercial extraction operations can be conducted with adequate land reclamation and minimal damage to water quality and supply.

Offshore oil and gas efforts will focus on projecting pollutant discharges and assessing control technologies to ensure protection and restoration of ocean shorelines. Problems of Western surface coal and oil shale mining will receive particular attention because of their profound impact on arid lands and the enormous potential of energy reserves in the West. The research will examine problems of revegetating arid mined land in the West. It will also examine the impact on groundwater from distruption of natural drainage contours and aquifers in coal seams. Efforts will also focus on underground coal mining problems, such as acid mine drainage and methods to close abandoned mines.

Fuel Processing--

This research area is best explained by examining four subcategories. Physical and chemical coal cleaning technology involves methods to physically or chemically remove sulfur from coal having a moderate sulfur content (1-2 pecent). This facilitates the burning of coal in conformity with clean air standards. The objectives of this research are to develop commercially available coal cleaning processes for organic and inorganic sulfur and ash in medium-sulfur coal and to develop methods for reclaiming or disposing of coal cleaning wastes in an environmentally acceptable manner.

Coal cleaning research will assess several technologies including several proprietary chemical coal cleaning pilot plants, a two-state froth-flotation physical cleaning process and advanced low-polluting, dewatering and drying technologies. Coal cleaning projects now in progress are designed to assess the environmental impact of these technologies, and promote the use of advanced coal cleaning methods for more efficient for pollutant removal. The Department of the Interior and ERDA are performing related research in this area.

Optimal fluidized bed combusion (FBC) processes could use coal, coal-derived products and residual oil more efficiently than other technologies and with little environmental damage. As part of the National Fluidized Bed Combusion Program which is coordinated by ERDA, EPA will conduct R&D to determine potential environmental problems from alternative designs and use of fluidized bed combustors. EPA's participation in this interagency program will consist of environmental assessment of future FBC systems by testing pilot-scale facilities and by continuing research using EPA's "miniplant" pilot installation.

EPA's research on synthetic fuels (high and low BTU gasified coal and liquefied coal) has two fundamental aspects:

- To determine the potential environmental impacts of synthetic fuel processing operations.
- To develop control technology to minimize potential environmental damage.

Environmental control technology R&D must be conducted concurrently with environmental assessments because some synthetic fuel processes - low BTU gasification in particular - are in the early stages of commercial demonstration. Development of an appropriate control technology must be accelerated to permit early commercialization and to avoid the diseconomies of forced retrofitting of pollution controls.

Consequently, environmental assessments will focus on characterization of feedstock materials at the same time that studies are conducted on the impact of shale-oil recovery, coal liquefaction and high and low BTU coal gasication. Technology to control air, water and solid waste pollution from conversion processes will proceed currently with fuel processing technology R&D being conducted by other agencies.

Under a level budget projection for the period, the following products could be delivered in the near term:

- Complete summary of all available treatment techniques for acid mine drainage from coal production. This document will provide information on technology available and costs of treating acid mine drainage.

- Complete an environmental instruction package for control agencies and operators concerned with surface mining. This manual will provide basis for State

- Regulations as well as training program to allow implementation of regulations.

- Complete assessments of environmental impacts of western coal development on areas of the Northern Great Plains.

- Complete multistream coal-cleaning demonstration at the Homer City power plant. Publish report on cleaned coal characteristics, on cleaning plant costs, energy consumption and environmental control and/or combustion characteristics of coal and compliance with standards.

- Publish a standard of practice manual for best available environmental control technology for physical coal-cleaning plants and for fluidized bed combustion facilities.

- Complete first year of Meyers process chemical coal cleaning operation. Provide cleaned coal to utility and industrial users for combustion testing. Publish a report on economics of Meyers process in comparison with flue gas leaning and the Homer City physical coal-cleaning technology.

- Complete environmental testing of the ERDA-sponsored Rivesville 30MW fludidized bed combustion pilot plant. This is the largest FBC unit presently under construction. The data from this testing is expected to lead to air and water standards for atmospheric FBC units.

- Complete environmental testing of the combined combustion, regenerator and granular filter in the Exxon fluidized bed miniplant. This will be the first operation of a completely integrated pressurized FBC system. It is at the process development unit scale.

- Complete report on environmental assessment of advanced oil processing technologies, including commercial oil gasification processes, oil desulfurization, demetallization and denitrification processes and advanced multi-stage and combustion processess.

- Complete Phase I environmental testing of the British Gas slagging Lurgi plant, and the ERDA Synthane and bigas gasification pilot plants.

- Prepare standard of practice manuals for best available environmental control technology for synthetic fuels processes for coal and oil shale.

- Complete construction of the in-house bench-scale coal-liquefaction environmental test facility and the wastewater treatment test facility. This will permit studies of the fate of various major and trace pollutants through different control technology.

- Continue environmental testing of all emerging fuel processing technologies and development of a data base to support NSPS and effluent guidelines.

- Complete assessment of the environmental effects of coal slurry pipelines.

On a longer range basis, outputs of the extraction R&D will define environmental problems associated with surface and underground coal mining in the Eastern and Western United States. Problems associated with active and abandoned mines such as mine drainage, groundwater pollution and reclamation will be considered. Also, methods, techniques and processes for control will be developed. Information similar to that developed for coal will also be developed for oil shale and tar-sands.

The prevention and control of oil spills will receive increased emphasis in later years. So will the determination of environmental impacts associated with offshore gas and oil exploration and development, liquefied natural gas (LNG) and liquid petroleum gas (LPG).

To promote greater use of coal, many processes are under development to obtain a clean fuel from coal. Anticipating these developments, major emphases in the early part of the EPA R&D program will be on obtaining environmental data to define potential problems associated with many synthetic fuel technologies being considered for development (e.g., high and low BTU gasification, coal liquefaction). Other technologies that are being developed and may allow coal and oil to be used with minimum environmental degradation, include fulidized bed combustion (FBC), advanced oil processing; chemically active fluidized bed combustion (CFB) and physical and chemical coal cleaning.

Since EPA does not have sole responsibility for developing the technologies that can allow greater use of coal, the EPA control technology program will continue to be coordinated with other agencies such as ERDA and DOI and resources will be set aside for interagency agreements.

Some of the objectives to be achieved later in the five-year period include:

- Completion of environmental testing of operating Eastern and Mid Western coal cleaning plants to support setting of standards for new plants.
- Evaluation (lab scale) of novel technologies to remove sulfur, nitrogen and hazardous trace materials from coal and coal cleaning wastes.
- Operation of the joint EPA/U.S. Bureau of Mines physical coal cleaning test facility to develop improved control technology.
- Completion of the development of pollutant sorbent regeneration and alternative sorbents for FBC systems to avoid a massive solid waste disposal problem.
- Completion of the development of high temperature and high pressure granular-bed filter fine particulate control technology for support of NSPS for pressurized FBC and gasification processes.

- Demonstration of energy and environmental benefits of the CAFB process residual oil gadification/cleanup at a utility boiler.
- Completion of bench-scale development of oil desulfurization, denitrification and demetallization technologies.
- Completion of environmental testing and development of manuals for control technology practice in support of standards for coal gasification, coal liquefaction, residual oil cleanup and oil shale processing.
- Completion of assessment of pollution potential of coal and oil shale mining in the Western U.S. and coal mining in Alaska.
- Completion of a demonstration of technology and development of manuals for clean-up of oil spills on land and water.
- Preparation of manuals of practice for protection and restoration of ocean, estuarine river and cool-climate shorelines because of oil contamination.
- Completion of manuals of control technology practice to support effluent guidelines for offshore oil and gas production facilities.

Potential Subprogram Growth Areas--

As the Nation moves toward developing alternate sources of energy it is becoming increasingly apparent that Western and Eastern coal will provide the bulk of near and mid-term energy resources. Additional funding would provide for more reliable assessments of the environmental consequences of surface and deep mining coal in different climatological regions. Additionally, cost-effective methods would be developed to control mine drainage polution in more widely varied circumstances, especially those at-source methods that provide reliable sediment and erosion control.

The increased use of coal will require an accelerated program of pre-combustion and postcombustion pollution control technology development testing and evaluation to insure the availability of a broad spectrum of cost effective control options. As coal is used more frequently to produce synthetic liquid and gaseous fuels to offset petroleum requirements, increased attention is needed to insure that these yet-unproven energy technologies are developed in an environmentally acceptable manner. Process effluents, as well as solid wastes from fluidized bed combustors and synthetic fuel processes, must be characterized and assessed to minimize harmful environmental insults. This activity will be performed in close conjunction with ERDA, and must be expanded to keep pace with their rapidly accelerating energy development program.

Additional outputs possible during the next five years if modest program growth is permitted include the following:

- Constructing and operating a chemical coal cleaning test facility. This would allow testing of various processes offering the potential of low-cost cleanup prior to combustion.

- Emissions testing and comprehensive pollutant analysis on additional synthetic fuel facilities.

- Initiation of a program for developing control technology for oil shale processing operations.

- Acceleration of the program to develop a high temperature/high pressure technology which will allow fluidized bed and gasification systems to minimize particulate emissions.

- Initiation of a critical component evaluation program for the Homer City full scale utility demonstration of physical coal cleaning to meet NSPS to ensure success of the demonstration and widen process applicability.

- Acceleration of evaluation and control technology development for disposal of FBC solid wastes.

- Preparation of a comprehensive treatment manual covering chemical and physical methods which is applicable to all energy mining activities.

- Comprehensive assessment of the environmental consequences of the newly developing mining methods in the various geographical regions.

Energy Conservation, Utilization and Technology Assessment Subprogram

Major emphasis in this subprogram is focused on the identification, characterization, assessment and development of control technology for pollutants associated with utility and industrial combustion sources. Attention will be given to developing information to facilitate the establishment of environmental standards and guidelines, and to the development of cost-effective control technology to achieve such standards.

The second aspect, energy conservation, calls for an assessment of potential environmental effects of advanced power systems and industrial process changes to achieve energy conservation. The third aspect, integrated assessment, will evaluate comprehensive environmental protection standards for energy production activities while attempting to balance environmental and economic costs.

Utility and Industrial Power--

The only way to significantly increase near-term coal use without severe environmental disruption is to have air pollution control technology available to meet Clean Air Act sulfur control requirements. Because coal conversion (gasification and liquefaction) processes seem promising but will not be ready for commercial application for quite some time, successful flue gas desulfurization R&D will provide the only viable coal-combustion control technique available in the 1970's. This will have greatest significance in regions that now rely less on oil and gas and more on coal, especially high sulfur coal for generating electrical power. Desulfurization systems, many in commercial operation or on order, are in final stages of development. R&D efforts will focus on remaining problems such as upgrading operating performance and reliability, minimizing costs, waste product disposal problems and treatment and by-product recovery. This should allow FGD technology to be more generally used in some regions. Funding for this work was expanded in FY 1975 to include capital for two advanced stackgas cleaning demonstrations. Funding levels will decrease in FY 1978 and subsequent years since no further full-scale utility demonstrations are scheduled.

Development of cost-effectve, commercially viable methods for control of oxides of nitrogen (NOx) from both existing and new stationary combustion sources is also important, since NOx emissions are extensive and could have widespread, adverse health and ecological effects. EPA's Maximum Stationary Source Technology (MSST) strategy places increased emphasis on controlling emissions from stationary sources. Because of the general lack of such control technology, this R&D is designed to increase the degree and effectiveness of NOx control from stationary sources.

EPA's overall program for control of stationary source NOx emissions relies primarily on development and demonstration of Combustion Modifications (CM) processes for utility, industrial, commercial and residential boilers. These processes minimize formation of nitrogen in the combustion zone. Such conrol measures should not reduce efficiency of combustion heat recovery nor increase emissions of other pollutants. An alternative approach that is being explored is "flue gas cleaning" involving flue gas treatment. _

Fine-particulate control technology to meet present and future emission reduction requirements is being developed by EPA. Emphasis is on controlling emissions from direct combustion of low-sulfur or cleaned coals and to develop cost-effective control devices for conventional and advanced coal combustion systems. Although particulate control technology has been used on combustion gases from high-sulfur content coals, low-sulfur content coal use presents a more difficult problem. In electrostatic precipitators, the most common control method used in utility boilers, lower sulfur content flue gas can degrade electrical of the precipitator and consequently, its performance. Injection of sulfur trioxide to improve electrical properties aggravates the secondary sulfate emission problem.

Combustion pollution assessment examines the overall impacts of all types of emissions. Potential health effects of metallic acid sulfates, trace materials and other fine particulates, may limit coal use in the future unless control processes are understood and technology developed to meet emissions standards. Cooperative efforts with EPA, ERDA and TVA, are underway to fuly characterize particulate emissions from conventional and advanced coal combustion systems.

Thermal control research responds to the Federal Water Pollution Act of 1972, wherein EPA is required to regulate thermal effluents. The research program responds to statutory requirements which include the following:

- Providing design and performance data for improved cooling systems.
- Reducing the dependence on use of rivers and lakes as heat sinks.

- Assessing the potential for waste heat reuse in agriculture greenhouses, aquaculture and cyclical storage.

Current efforts include advanced waste heat control using cooling towers and evaluation of chemical pollutant discharges from power plant cooling systems and development of effective controls.

Conservation --

Improved efficiency in fuel use is a potentially attractive way to help achieve energy self-sufficiency. But work is needed to assess potential environmental impacts of improved or advanced energy systems. Research efforts will concentrate in four areas:

Industrial Processes--Industrial process changes resulting from increased energy costs or governmental policies may produce unanticipated pollutant emissions or be environmentally superior to existing technologies. Accompanying environmental assessment and technology development work is needed in this area. Environmental R&D on energy-saving industrial processes will expand in the next few years.

Advanced Power Cycles--Work on advanced power cycles such as gas turbines, magnetohydrodynamics and fuel cells must be accompanied by identification, measurements and analysis of health and ecological effects of pollutants emitted.

Energy from Wastes--Several methods of using urban and rural waste materials as energy sources are being investigated. As a result, it is now technically and economically feasible to use municipal solid waste (MSW) as a fuel substitute in certain coal-fired power plants. Continuing investigations are designed to include co-firing MSW with coal in a smaller (stoker) boiler, conversion by pyrolysis to synthetic gases, liquids, and solid fuels, and studies of technical and environmental factors showing the implementation of wastes as fuel systems. If successful, these projects will show that energy recovery from MSW is feasible throughout the country for smaller cities and areas where coal is not used. Pollutant characterization studies are also being made to ensure that potential environmental problems are defined.

Advanced Energy Systems--In keeping with its general philosophy of anticipatory R&D for energy systems that will be developed over the long-term, EPA has begun assessment studies to provide baseline information about potential environmental impacts of geothermal and solar energy systems.

Integrated Assessment--

Environmental, economic and social consequences of energy alternatives together must be used as a basis for EPA policies. Projects are designed across entire technologies and fuel cycles to multifaceted effects on natural and human-modified environments of energy development and related activities. The alternatives for controlling environmental pollution associated with those activities are also examined. Studies will focus on environmental, economic, social and institutional impacts of various technologies under alternative environmental management approaches.

Under continuing budget constraints similar to FY 1977, the following products listed below would be produced in the near-term by the Conservation, Utilization and Technology Assessment Subprogram:

- Initiate construction of the double alkali (non-regenerable) and aqueous carbonate (regenerable) full-scale flue gas desulfurization demonstration facilities. These second generation systems offer performance, economic and operability improvements over present systems.

- Perform a comprehensive application testing program aimed at identifying means of controlling NOx via operational modifications for selected combustion sources. Stationary combustion sources produce over one-half of man-made nitrogen oxides emissions.

- Develop and apply NOx control technology employing combustion modifications to utility boilers, commercial/industrial boilers, residential heating systems, stationary engines, and advanced combustion processes. These combustion systems represent the major stationary sources of nitrogen oxides emissions.

- Undertake programs to improve the effectiveness of conventional electrostatic precipitators, fabric filters, and scrubbers for fine particulate removal. Fine particulates are potentially deleterious to human health and are difficult to cost-effectively control with conventional control technology.

- Complete the Shawnee advanced lime and limestone test study and publish a final report. This activity is aimed at identifying improved process capable of increasing sulfur dioxide removal economics, reliability and sludge characteristics of the most commercially important FGD process (lime/limestone).

- Identify and characterize various waste streams, and perform emissions and residuals studies on pollutants inherent in wastes or produced in resource recovery and energy conversion processes. Develop pollution control techniques for waste reuse processes which cannot meet environmental standards.

- Develop systems for co-firing wastes with coal in industrial-sized boilers and for co-firing wastes with oil in large utility boilers. These systems, along with the "St. Louis" technology already developed by EPA, should make possible conversion of 50 percent of the Nation's municipal solid wastes to energy.

- Develop an inexpensive processing system for producing fuel from refuse. This system will make recovery of wastes competitive with disposal in smaller and middle-sized communities.

- Perform studies to evaluate the cost/risk/benefit trade-offs of energy production, conservation, and pollution control alternatives.

- Complete the technology assessments of energy development in the Western U.S. and the activities of the electric utility industry. Publish comprehensive reports of the results, and conduct seminars describing these results.

Emphasis in the early part of the five-year period is on obtaining the outputs from the flue gas desulfurization (FGD) work. Data from test programs for nonregenerable FGD systems will provide data for evaluation as will supporting studies involving by-product marketing and sludge disposal from FGD systems. All data generated from the FGD R&D is expected to be given to regulatory groups and user industries through the technology transfer program.

As the FGD R&D peaks and tails off, emphasis and resources of the energy program will shift to NOx control, fine particulate control, thermal control and conventional combustion pollution assessment.

The NOx control program will include field testing and characterization studies and development of control technology for gas turbines and utility, industrial and commercial boilers. NOx control for residential heating systems will also be considered. Simultaneous removal of SOx/NOx by way of flue gas cleaning technology will also receive attention.

The fine particulate control program will also accelerate as effort is made to determine the effectiveness of available control equipment, to improve existing control equipment capability and to demonstrate the efficiency of novel devices.

The expectation is that environmental assessment of conventional combustion systems will allow for an informed, orderly identification and ranking of pollutants and their potential impact according to pollutant media (e.g., air, water, solid waste). This approach will guide EPA and its R&D program in determining adequacy or inadequacy of existing and planned programs.

Conservation studies should continue at a relatively constant rate. Analyses of use of wastes as fuel, assessment of advanced cycles, assessment of advanced energy systems and industrial conservation are expected to provide data on potential environmental impacts of those technologies to guide R&D program planning.

With no program expansion, outputs in the latter part of the period would be limited to the following:

- Complete the Shawnee sludge demonstration evaluation program. This involves a pilot test of three commercially offered sludge-fixation processes and follow-up environmental evaluations.

- Complete the Bahco test study for lime scrubbing on a coal-fired industrial boiler and publish a final report. This will evaluate a sulfur control option for smaller combustion sources.

- Complete a final report on the Wellman-Lord FGD demonstration. This report will summarize operational performance of the first application of this FGD technology to a coal-fired power plant. Sulfur will be produced as the end product.

- Issue a final report on Louisville Gas and Electric lab and field FGD waste-disposal studies. The objective here is to understand and apply the unique chemistry of this successful unit to other applications and improve sludge-disposal technology.

- Prepare annual reports summarizing the EPA-sponsored FGD sludge effort encompassing evaluation studies and pilot and prototype-scale testing.

- Complete preliminary studies assessing the impact of gas, water and waste streams from a variety of combustion sources. Such studies aim at characterizing the problems associated with presently unregulated pollutants associated with fossil fuel combustion sources.

- Perform a comprehensive application testing activity aimed at identifying means to control NOx through operational modifications for a wide variety of combustion sources.

- Develop and apply NOx control technology employing modifications to utility, commercial and industrial boilers, residential heating systems, stationary engines and advanced combustion processes.

- Develop promising flue gas cleaning methods for NOx control at the small pilot level. Such systems offer potential for enhanced NOx emission control from large combusion sources.

- Enhance the effectiveness of conventional particulate control devices for fine particulate removal including electrostatic precipitators, bag-houses and scrubbers.

- Select, test and evaluate one promising, novel fine particulate control device at the pilot level.

- Analysis of wet-and-dry and dry cooling tower technology capable of dissipating waste heat from steam-electric plants at the prototype level while minimizing water pollution and water supply problems associated with wet cooling towers.

- Perform economic, technical and environmental evaluations of resource recovery systems and refuse-derived fuel-processing and energy-recovery equipment and systems.

- Assess the air qualty inside various types of buildings in relation to energy conservation approaches and outdoor air quality.

- Evaluate the potential environmental impacts of the following advanced cycles: high-temperature open and closed-cycle gas turbines; Magnetohydrodynemics; potassium topping cycles and thermionics.

- Conduct environmental assessment studies and evaluate environmental control technology needs for geothermal and solar energy systems.

Potential Subprogram Growth Areas--

Level funding over a five-year period would constrain efforts in the areas of NOx, SOx, and fine particulate control technology development. In light of the increasing emphasis on fossil fuel combustion, it appears likely that high levels of control of these pollutants will be necessary from a wide variety of sources to avoid deleterious environmental impacts. Also, emissions of these pllutants may be important precursors to the production of potentially deleterious secondary pollutants such as sulfates, nitrates and nitrosamines. Modest program growth would allow development of control technology for increasing pollutant removal capability, increasing the number of sources for which control technology would be available and improving the economics of first generation control technology.

Level funding also limits efforts in the areas of wastes-as-fuel, industrial energy conservation, advanced energy cycles, advanced energy systems, and energy conservation in the built environment. It appears likely that control of pollutants from these source areas will be necessary from a wide variety of technologies to avoid deleterious environmental impacts. It also appears likely that several technologies in wastes as fuel and the industrial sector can be brought to commercial practice which mitigate environmental problems associated with conventional practices. Modest program growth would permit development of these new technologies, along with more efficient and effective control systems.

The following products could be delivered before 1982 if modest program expansion were authorized.

- Demonstrate first and second generation nonregenerable and regenerable flue gas desulfurization technologies capable of reducing SOx emissions by greater than 95 per cent.

- Accelerate the development and application of low-cost NOx control methods (employing combustion modification techniques) for residential and commercial combustion sources.

- Initiate a demonstration program for flue gas desulfurization control from one or more industrial combustion sources.

- Co-sponsor with an electric utility an integrated magnesium oxide flue gas desulfurization system on a full-scale coal-fired power plant. Magnesium oxide is a near-term technology offering the potential for favorable economics and avoidance of a solid waste disposal problem.

- Accelerate development of technologies allowing control of fine particulate emissions from combustion of low sulfur fuels.

- Demonstrate at a full-scale installation the fixation and environmentally acceptable disposal of flue gas desulfurization waste sludge.

- Expand present integrated technology assessment efforts relating to the electric utility industry to include the smaller combustion sources, e.g., residential, commercial and industrial sources.

- Accelerate development and demonstration of environmental control technologies for wastes as fuel systems (e.g., heavy metals removal techniques).

- Develop and demonstrate on a joint basis with industry technologies to improve the energy efficiency of glassmaking and textile dying by 30 percent and simultaneously reduce uncontrolled emissions.

- Complete the development of environmental assesssments and techniques for assuring the environmental soundness of geothermal and solar energy development.

- Expand environmental assessments of advanced energy cycles to include the measurement of pilot plant emissions and to perform related laboratory work on environmental parameters.

MONITORING AND TECHNICAL SUPPORT PROGRAM

The Monitoring and Technical Support Program includes measurement research, development and demonstration activities and direct assistance and support to all of EPA. Subprograms include Measurement Techniques and Equipment Development, Quality Assurance, and Technical Support.

Measurement Techniques and Equipment Development involves development, evaluation, and demonstration of field and laboratory measurement and monitoring methods and instrumentation. Efforts are directed toward achieving capability to identify and measure all pollutants of concern in the most cost-effective manner. The subprogram is further divided into the elements of Characterization and Measurement Methods Development, and Measurement Techniques and Equipment Standardization.

Quality Assurance serves all environmental monitoring activities of EPA. This activity focuses on standardizing measurement methods, providing standard reference materials and samples, developing quality control guidelines and manuals, conducting onsite evaluation of analytical laboratories, inter-laboratory performance tests, crosscheck samples studies, methods for laboratory accreditation, automation of laboratory instruments and data handling, and participation in regional quality control activities.

Technical Support is the scientific and technical assistance the research program gives to other components of EPA using the expertise of ORD personnel and available ORD facilities. This subprogram includes programs to deliver results of ORD's efforts to its users by technical information dissemination. This effort assures that R&D programs will be more responsive to immediate operational needs of other components of EPA.

Technical Support also includes minority institutions research support (MIRS), an effort to direct research grants to minority institutions. Minority institutions that have or can develop capability to conduct effective environmental research are actively sought, and encouraged to participate in the extramural research program.

Monitoring, Techniques and Equipment Development Subprogram

In administering the Federal environmental protection laws, the Agency requires reliable, quantitative information on extent, concentration and trends of environmental pollution. This information, obtained through environmental monitoring, is necessary for several purposes:

- To assess compliance with ambient environmental quality standards.

- To assess compliance with effluent and emission permit requirements.

- To assess impacts of unregulated pollutants in the ambient environment.

- To quantify risks of pollutant exposure-effect relationships for important receptors.

- To understand linkages between significant sources of discharge and ambient levels of pollutants.

The objective of Monitoring, Techniques and Equipment Development Subprogram is to develop equipment and methods that are accurate, simple, standardized, cost-effective and responsive to requirements for environmental monitoring by Federal, State, and local governments and by the private sector.

Monitoring methods for health and ecological effects require high performance reliability at very low concentration levels necessary to relate adverse effects with low doses of pollutant in air, water and plant and animal tissues. Methods to measure impacts of heat, radiation and noise on important receptors are also required. Highest priorities for such methods development are given to pollutants that toxic, carcinogenic or otherwise hazardous.

Characterization and Measurement Methods Development--

This research area is directed toward production of pollutant measurement concepts, methods, and procedures which can be made sufficiently accurate, reliable and economic to meet the needs of pollutant measurement and ambient environmental quality characterization. The research covers a broad range of pollutants and measurement methods, as shown by the following examples of near-term accomplishments in the air pollution areas:

- Sampling technique for measuring total arsenic and selenium.

- Sampling and analysis technique for halogenated organic carcinogens.

- Design for field operation of a multi-wavelength laser backscatter system for remote monitoring of sulfur dioxide and other pollutants (possibly nitroten dioxide and ozone).

- Report on the characterization of toxic trace metals from stationary sources.

- Characterization of gaseous emissions from gas turbines burning residual fuel.

- Report on characterization of organic emissions from petrochemical sources.

- Development and evaluation of fuel-additive related control system performance protocol.

- Report on the characterization of gaseous and particulate emissions from non-catalytic advanced control devices.

- Report on the development of prototype in-situ measurement system for quantifying sulfuric acid emissions from stationary sources.

- Report on chromotographic analysis technique for nitrosamines in ambient air.

- Report on the development of a prototype nitirc acid analyzer for ambient air.

- Development of prototype sampler for PCB's.

- Report on the evaluation of solid sorbents for the collection and analysis of nitrogen and sulfur oxides.

- Report on the development of methods for identification of selected carcinogens and nitrogens.

- Develop Low Cost Manual Dichatomous Sampler.

- Characterization of amonia, nitrogen dioxide and oxides on selected major roadways in the northeast and California.

In the water pollution area, measurement methods exist for most elements, viruses and for volatile organics (about 10% of the total organic content water). However, all of these methods need significant improvements if they are to be used extensively. In the case of non-volatile organics (the other 90% of the organic content of water) analytical procedures are non-existent and the need for such procedures increases each day as greater and greater emphasis is placed on toxic substances.

Of immediate concern are the improvements needed in elemental and volatile organic analytical methods and instrumentation. In both cases sampling and sample preparation procedures must be developed and optimum conditions for quantification must be established. Non-volatile organics present a longer term but equally pressing problem. These substances include many known toxic substances such as nitrosamines and natural and man-made polymers. Because of the varying chemical and physical properties presented by the non-volatile organics, procedures will have to be developed for several groups within this class of substances. While methods for viruses and for identification of elemental species are not as pressing the need for improved or new methods in the next several years is well recognized.

Near-term program outputs include the following:

- Automatic sampler for volatile organics in water.
- Improved procedures for more efficient identification of volatile organics.
- Methods for use of plasma emission spectrometer for simultaneous multielement analysis.
- Characterization of municipal and organic phosphate manufacturing waste waters.
- Development of a technique to confirm identity of organic substances initially identified by mass spectrometry.
- Development of procedure for transport of field-collected virus samples.

The current air pollution measurement and characterization effort is expected to continue over the next five years to pursue instrument development and sampling and analysis techniques to support characterization programs and standard-setting activities. However, the following shifts in emphasis will take place:

- There will be an increased emphasis on stationary source measurements of non-regulated pollutants in support of the expected acceleration of New Source Performance Standards (NSPS) that will be set over the next five years.
- Greater emphasis will be given to measuring and characterizing emissions of non-regulated pollutants from mobile and stationary sources, such as vinyl chloride, specific organics, sulfates, halocarbons, trace metals, nitrates, nitrosamines, hydrogen cyanide and hydrogen sulfide. This, of course, will place a greater emphasis also on instrument and analytical methods development for these substances.

- Greater emphasis will be given to the development of long-path optical techniques for measurement of air pollutants, and application of these techniques to specific problems.

Examples of possible outputs are given below:

- Development of an nitrogen oxides specific instrument to detect low concentration levels in rural atmospheres.
- Development of sampling and analysis techniques for toxic organics from diesel-powered vehicles.
- Fabrication of automated collectors for studies of natural emissions sources of sulfur compounds.
- Development of semi-real-time aerosol sulfur monitor.
- Development of automated sulfuric acid analyzer.
- Characterization of gaseous and particulate emissions from non-catalytic advanced control devices for light-duty vehicles.
- Characterization of toxic organic aerosols from industrial sources.
- Characterization of organic emissions from petrochemical sources.
- Analysis of sulfur oxide emission data for oil-fired power plants.

In the first few years of the five-year forecast period in water pollution the major push will be on the needed improvements in elemental and volatile organic methods. These improvements are critical to agency activities associated with Effluent Guidelines, NPDES and newly planned Water Quality Monitoring program. The need for high accuracy over wide ranges of concentration and for reliability and high throughput are critical if EPA regional offices and State agencies are to be effective in carrying out these programs.

Efforts will be shifted to methods for non-volatile organics and inorganic species of concern, e.g. asbestos, as suitable methods are established for volatile organics and trace elements. At the present resource level, the shift of effort will not produce substantial results within the five-year period.

For viruses, the emphasis will be on pushing existing techniques to the limit recognizing that new approaches will have to be sought if they are to be monitored more widely than at present. Characterization of effluents will be decreased to a minimal level depending entirely on external sources for information.

Measurement Techniques and Equipment Standardization--

The objective of this research area is to develop, test, and evaluate multimedia equipment and methods that are accurate, standardized, cost-effective and responsive to requirements for environmental monitoring by Federal, State, and local governments and by the private sector. These methods must not only be applicable at lowest environmentally significant ambient concentrations, but must also be applicable at higher concentrations that occur at pollutant sources.

Operational monitoring methods development gives highest priority to regulated pollutants. These methods are being developed for routine use in ambient environmental monitoring and for self-monitoring by point-source dischargers and those responsible for compliance monitoring.

Activities in this area include design and optimization of monitoring systems and networks, development of airborne and remote sensing techniques, development of automated techniques for field application, data handling systems, and development of environmental monitoring instrumentation.

In development of multimedia monitoring methods, the usual technique is to adapt or modify known measurement technology to meet given field requirements. An interdisciplinary approach is taken to insure adequate methods are available for biological, chemical, physical and radiological pollution. Effective liaison is conducted with other Federal Agencies to assure orderly transfer of appropriate technologies to the Agency's programs.

Included within this program is the registration of fuels and fuel additives. The information acquired provides a data base which is used to forecast motor vehicle emissions which have a potential for adverse impacts on human health and welfare. This information base also provides a basis for anticipating effects from fuels or fuel additives on emission control devices.

In the near term, the subprogram will continue to provide the most efficient and cost-effective monitoring techniues possible to meet the needs of the Agency and related State monitoring program:

- Publication of methods for measuring organic pesticides, PCB's, selenium, oil and grease, chlorinated organics and kepone in water and solids;
- Correction of deficiencies in existing reference methods used for monitoring municipal and industrial waters in the NPDES program, for the enforcement of National Interim Primary Drinking Water Regulation and for monitoring ambient fresh and marine water;
- Development of reference methods based upon a computerized Gas Chromatograph/Mass Spectrograph system with emphasis on lowering the detection limits for reliable identification of pollutants to levels consistent with proposed standards and to extend the technique to include additionally identified toxic substances;
- Development of a more sensitive bioassay technique for the detection of toxic hazardous substances in waste water;
- Development of methods to detect nonpoint source pollutant discharges, e.g. urban run-off and agricultural sources;
- Demonstration of a prototype sampler for NPDES monitoring of organic compound at lower costs;
- Extension of test methods to include measurement of pollutants contained in municipal sludges as well as other wastes presently discharged into the ocean;
- Development of a remote sensing system for plume identification by particle signature and for measurement of plume mixing patterns;
- Testing of a more rapid automated in-situ sensor for measurement of coliform bacteria;
- Testing of an air deployable package for surface temperature measurement to provide a reference point for data collected with remote temperature sensors;

- Continuation of the fuels and fuel additives program including registering of motor vehicle gasolines and diesel fuels, engine oils and collection and analysis of samples of registered products;

- Development and validation of guidlines for an optimized integrated network for air and water quality monitoring;

- Development and validation of biological response as a measure of pollutant exposure;

- Development and application of systematic multimedia monitoring concepts for toxic substances and carcinogens;

- Development of a LIDAR method for monitoring ozone to aid in oxidant transport studies.

Later in the five-year period, the Measurement Equipment and Techniques Standardization area will develop, update and revise analytical methods systems and manuals. Correcting deficiencies in present reference methods and standardizing new reference methods in response to needs to measure specific high priority pollutants will continue to receive the highest emphasis in the program.

The MTES activity for water methods will, as an overall objective, continue to develop revised analytical methods and manuals, including extension of the present test procedures mandated under Section 304 (g), PL 92-500 to pollutants contained in sludges and ocean disposed wastes. The program will focus on developing low level response implant bio-monitoring methods, identification and detection of water-borne viruses by immunoenzymatic methods, development of a portable virus concentrator for field recovery of viruses, and preparation of a second edition of the Biological Methods manual.

In the interdisciplinary area, multimedia monitoring methods development efforts will result in the design of two-wavelength line LIDAR for measuring particulates together with the design of a Differential Absorption Spectrometer system for mapping ozone. The development of a laser fluorosensor for detecting oil and algae is also planned, as well as the test and optimization of the aerial infrared scanner for thermal pollution discharges into water. Development of a quantitative multi-spectral scanner system for measuring water turbidity will also be completed. The work will include development of automated in-situ waterborne sensors for measuring turbidity, pH and salinity; and an improved nonpoint-source monitoring method for the extraction industries. An assessment of a unique visibility monitoring technology, network optimization for measuring reactive pollutants and network design procedures for all pollutants will be completed by FY-82. Integrated monitoring for determining mass balance of selected pollutants and for determing exposure routes to critical receptors will be completed, as will testing of a bio-indicator network integration system.

Potential Subprogram Growth Areas--

Because of the vast number of environmental pollutants for which standard, reliable measurement methods are not yet available, the backlog of needs will still be large in 1981 if the subprogram is constrained by a level budget. If, however, modest growth is authorized, the following additional products could be delivered by 1981:

- Reliable sampling and analysis procedure for sulfites.
- Remote point source and area monitors for measurement of mass emission rate of sulfur oxides from industrial (wide area) sources.
- Semi-specific cartridge for ambient air sampling of toxic, carcinogenic or reactive organic vapors.
- Determination of emission concentration levels of toxic organics from light- and heavy-duty diesel vehicles.
- Characterization of nitrosamines in the ambient environment.
- Determination of emission concentration levels of toxic organics from losses in production, storage, and use of petrochemicals.
- Proton scattering technique for determining mass balance in aerosols.
- Flash lamp induced fluorescence for direct measurement of nitrogen dioxide with negligible interferences.
- Application of long path optical techniques to the measurement of toxic organic vapor emissions from petrochemical plants.
- Determination of ambient air concentrations of toxic organics in industrial and urban areas.
- Preliminary potocols for identification of individual members of one or two groups (probably acids and bases) of non-volatile organics will be available.
- Characterization of major industrial effluents at the present rate of about two per year.

- Perfection of methods for multielement analysis of sediments sludges and soils.
- Significantly improved and standardized procedures for viruses in water and sludges.
- Development and standardization of "second generation" air monitoring systems.
- Accelerated development of standardized methods and screening procedures for toxic materials.
- Screening methods for mutagens and carcinogens.
- Improved methods for detecting viruses and other pathogenic microorganisms.
- Scanning capabilities for LIDAR system for synoptic monitoring of air pollutants.
- Expand LIDAR to include sulfur dioxide monitoring from sources and during transport and transformation.
- Laser fluorosensor system for monitoring aromatic hydrocarbons and dissolved organics.
- Automatic in-situ sensor for monitoring oil films in coastal zones.
- Automated in-situ sensors for dection of metals and pesticides in water.
- Standard procedures for monitoring nonpoint sources of water pollution in support of 208 Agencies.
- Methods for monitoring diffusion and transport of pollutants over large areas
- Continuation of the fuel and fuel additives programs.

Quality Assurance Subprogram

Environmental data produced by Federal, State and local monitoring activities must be accurate, intercomparable, and legally defensible. The Quality Assurance (QA) subprogram is responsible for developing and implementing a comprehensive Agency-wide quality assurance program to achieve these goals.

Major activities include:

- Statistical validation and standardization of total measurement systems (development of site selection and validation criteria, flow measurements, sample collection and preservation, analyses, and data output).
- Development and distribution of standard reference samples and materials.
- Preparation and distribution of quality control guidelines and procedures.
- Evaluation of monitoring activities (evaluation of facilities, equipment, operators, procedures and performance).
- Development of automated laboratory management systems (application of minicomputers to laboratory instruments, data screening, computerized statistical quality control).
- Technical assistance (assistance in carrying out calibrations, split samples, etc.).
- Development and participation in regional quality control workshops, conferences and seminars.
- Development and implementation of a measurement methods equivalency program to support the National Pollution Discharge Elimination System (NPDES)
- Development and implementation of a measurement methods equivalency program to support the analytial requirements of the Safe Drinking Water Act.
- Validated procedures for the collection and preservation of water and wastewater samples.
- Completion and preliminary evaluation of currently available methodologies which can be used to measure the 65 toxic pollutants in the "Consent Decree."

- Continuation of a measurement methods equivalency program for stationary air pollution emission sources.
- Standardized and validated measurement systems for air, water, wastewater, pesticides, and radionuclides as determined by monitoring program priorities.
- Procedures and acceptance criteria for testing and officially approving methods alternative to reference methods promulgated by the EPA.
- National work plan to coordinate and carry out the functions of the Pilot Secretariat for pollution measurement under the authority and auspices of the International Organization for Legal Metrology.
- Manual of measurement methods for ambient air and stationary emission sources.
- Manual of evaluation procedures and acceptance criteria which can be used to certify capabiliity and performance of laboratories analyzing public drinking water under the Safe Drinking Water Act.
- Development of repositories of reference and quality control samples and materials for air, water, pesticides, radionuclides, and other measurements as needed for calibrations testing and quality control.
- Quality control guidelines for the measurement of nitrogen dioxide in ambient air, and a technical guidance document for the use of continuous nitrogen dioxide monitors.
- Performance specifications and performance evaluation reports for continuous water quality monitors and automated samplers.
- Interlaboratory performance tests for air and water measurements and cross-check sample studies for radiochemical measurements to include support to the Nuclear Regulatory Commission.

- Technical assistance to the Regions/States to upgrade environmental laboratories relative to performance and quality control: semiannual meetings of all Regional quality control coordinators; participation in planning and conducting quality assurance workshops and seminars; and direct technical assistance to solve operational monitoring problems and to provide the on-site evaluation of laboratories, particularly for laboratories making radiochemical measurements.

The quality assurance research and development outputs are essential to the success of the Agency's total monitoring efforts in all media and special categories. The availability of resources (both positions and dollars) and the state of measurement methods research determine the number and types of monitoring programs that can be covered. As monitoring requirements change, new measurement systems will be validated and new quality control practices will be instituted and maintained. Consequently, the activities of the quality assurance program may look the same from year to year, while addressing entirely new and different types of monitoring problems.

In FY 1978 and beyond, the water supply QA activities will continue to satisfy the minimum mandates of the Safe Drinking Water Act. While the States will assume primary responsibility for implementing programs to assure the safety of public drinking water, the EPA must certify the State's capability to carry out the program and must provide standardized measurement systems, technical guidance, program overview, and a national quality assurance support program for the States. Of paramount and immediate concern is development of standardized measurement systems that can be used for routine determinations of pesticides, radionuclides, and traces of toxic organic substances in potable waters. No less important is development and maintenance of quality control efforts to assure that all data generated are statistically valid and legally defensible. Quality control outputs will include development and distribution of reference and quality control samples; conduct of periodic interlaboratory performance tests; and direct assistance in the on-site evaluation of laboratories.

The subprogram will continue to support regional office implementation of the Safe Drinking Water Act by providing a quality assurance expert in each region for certification of state water supply laboratories, a manual for laboratory technical evaluation procedures and acceptance criteria and one national interlaboratory performance test, and a program to provide technical review and evaluation of proposed alternate procedures for compliance analysis of controlled drinking water contaminants.

Quality assurance efforts in the area of wastewater measurements will result in the validation of test procedures and the establishment of quality control practices to meet monitoring requirements of PL 92-500. Of major concern will be performance and data audits for discharge monitoring reports for the National Pollution Discharge Elimination System (NPDES) permit program, and a measurement methods equivalency program for waste water effluents.

In the air measurements area, the on-going efforts are critical to the implementation of the national ambient air quality and emission standards for stationary sources. A level budget schedule will allow for a continuation of current standardization and quality control activities, including the standardization of atmospheric particulate lead method (s) and the interlaboratory performance tests for ambient air measurements.

In the radiation measurements area, resources will allow a level of effort in continuing the cross-check sample studies, some measurement methods standardization, and minimum assistance to the Regions in the on-site evaluation of State radiochemical laboratories.

In the pesticides measurement area, other than water and wastewater the subprogram will continue to provide standard methods, reference samples, and quality control procedures for analyses of pesticide residues in tissues, blood, urine, mothers milk, etc.

An important aspect of the program will be the continuous evaluation of performance of Federal, State, and local monitoring support laboratories. This activity will also support the Nuclear Regulatory Commission's evaluation of their licensees' capability to make accurate and precise measurements of radioactivity in the environment and technical assistance and guidance to assist those laboratories found deficient.

Potential Subprogram Growth Areas --

Modest growth in this subprogram would support new efforts for water supply measurement methods standardization, preparation of reference samples, guidelines, and assistance to Regions in on-site evaluation and certification of laboratories. Increased resources would also be used to develop new procedures for radiochemical measurements and a minimal quality assurance program for wastewater discharge monitoring reports.

In the outyears, additional resources would focus on developing and implementing a comprehensive quality assurance program for potable water measurements, including laboratory certification; quality control practices for wastewater discharge monitoring reports, including on-site inspections; accelerated standardization of methods for toxic pollutants for both air and water; performance audits for stationary source measurements; development of quality control programs for biological and microbiological monitoring activities and correction of deficiencies in performance of measurement systems and operators.

Technical Support Subprogram

The Technical Support program is responsible for assuring that the expertise of ORD personnel, specialized ORD equipment and the knowlege gained from research are made available to Agency operating programs in response to specific requests, dissemination of the latest information resulting from ORD programs through a technical information process and enhancing the capabilities of minority institutions to acquire Federal support.

Technical Services--

ORD assists other parts of the Agency whenever possible by providing specific or unique scientific expertise and special scientific equipment and instruments. Resources associated with these efforts are planned for and provided from the air, water quality and interdisciplinary program elements associated with the three Environmental Monitoring and Support Laboratories (EMSL's). A portion of the overall technical support program as it pertains to all ORD laboratories is provided in the base R&D program as nondiscrete tasks to provide resources for unforeseen ad hoc activities as they occur, which are outside the existing capability of the EMSL's. These activites may include such things as expert testimony in legal actions (e.g. concerning health effects requiring an expert from the Health Effects Research Laboratory) and short-term consultant services.

Of the planned services, many of the efforts required by the program and regional offices are on a continuing basis and have become routine in nature, as opposed to emergency or short-term responses. ORD continues to provide these services even though they are routine either because their costs and manpower requirements, or their EPA-wide nature would make it difficult or impossible to duplicate these capabilities in the program and regional offices. Examples of this include trace element analyses of National Air Sampling Network samples, analyses of the Fuels Surveillance Network samples; and maintaining the aircraft capability for aerial surveillance and monitoring, as well as the capability to assess point and nonpoint sources of pollution from aerial photographs.

The near-term program for air technical services includes completion of contact sensing and sampling to determine the impact of aircraft operations on air quality, vegetation and soil at a major municipal airport; and the continuation of a multi-year oxidant study in the Tampa/St. Petersburg area in which data is being collected to validate an urban source grid model for use in developing State Implementation Plans. Other continuing efforts include international monitoring activities; guidance and assistance in the design, implementation and operation of field and laboratory systems to collect and/or measure valid environmental samples; and evaluation of instruments and methods, assessment and analysis of the data and issuance of reports. In these efforts emphasis will be given to pollutants of proven or potential adverse effects to human health and welfare including polycyclic organic trace chemicals. New activities will include initiation of a plume characterization study (using instrumentation aircraft and ground-based monitors) designed to provide data for State sulfur dioxide regulation hearings; follow-up to the New York urban plume oxidant, sulfur and aerosol transport study to characterize and define the transport of the plume under varying meteorological conditions; a companion study to the Tampa/St. Petersburg oxidant transport study to define the nature and extent of the urban plume as characterized by oxidants; and a sulfur dioxide monitoring study in Hawaii.

The water technical services progam will continue monitoring for viruses in wastewater treatment, sludges, lake, river and ocean samples; special performance evaluation studies for certification of water supply laboratories; and the Atchafalaya Basin water quality study which is developing data for water quality management as part of an Interagency Study Group program examining the impact of Corps of Engineers water control activities. Tasks to be completed shortly include the study of Lake Tahoe and its drainage basin to determine the nutrient budget and lake productivity; the trophic classification of Illinois lakes using satellite data; and a special water quality study of Lake Powell and San Juan River to evaluate energy development and production impact. Other efforts include the chemical radiological analysis of data acquired from the Lake Eutrophication Survey; assessment of agriculture and silviculture practices related to water quality based on aerial photographic surveys; and the determination of transport and dispersion of effluent plumes from certain power plants.

The interdisciplinary technical service program of airborne monitoring and surveillance includes studies of sanitary landfills to determine the movement of leachate; delineation of land-use patterns and pollution sources; surveys of strip mine areas to determine causes and sources of acid mine wastes and effects of rehabilitation practices; wetlands inventory of six coastal states; spill prevention control and counter measures surveys; a hazardous material disposal site survey; and a 100 site study for noise regulation model verification support. Provisions are also made under the interdisciplinary technical services program to provide analytical services in support of the water supply program.

Over the next five years, the technical support program will continue to provide assistance to the Agency, but at a reduced level, reflecting reduced personnel authorizations. Routine services, heretofore provided, but which are potentially within program office capabilities will be terminated in FY'78. ORD will continue to provide only those services beyond the scope of program office capabilities. ORD personnel and equipment will remain available to the Agency for critical needs.

The air technical services program will continue to apply the latest improvements of methods, equipment and techniques for the measurement and quantification of ambient air contaminants. It will concentrate on non-regulated pollutant characterization, measurement of trace metals and organic emissions from stationary sources and methods for identification of carcinogens and mutagens.

The water technical services program will provide technical expertise and consultation, and laboratory support services for Agency operating programs on matters related to the analyses of water, wastes and sediments.

The interdisciplinary technical services program will include airborne monitoring and surveillance and will provide resources for responding to immediate Agency needs for technical services.

Minority Institutions Research Support (MIRS)--

The MIRS activity awards research grants to minority institutions to stimulate environmental research consistent with EPA requirements and to enhance the competence of these institutions. To assure that grants are based upon actual requirements, they are structured upon a cost-sharing basis between this activity and the main ORD unit sponsoring the research requirement. Requirements are made known to minority institutions, and those possessing expertise in the necessary discipline are encouraged to develop appropriate research proposals.

It is planned to maintain the MIRS activity at its current level throughout the five-year period. Subjects addressed by the grants will reflect priorities in the overall research program.

Technical Information--

This activity is responsible for managing and coordinating the effective dissemination and transfer of the products of the research and development program to a variety users both within the Agency and throughout the public and private sectors. The effort involves the entire range of general scientific and technical information dissemination activities including such normal activities as the publications and general distribution of scientific and technical reports and responding to requests for specific information on publications. A special effort is made to match available information or technology with the expressed needs of particular user groups such as local community decision officials who frequently do not possess technical or scientific backgrounds. Appropriate information transfer products are then developed in a form designed to be most useful and readily understandable to the targeted user. Such specialized products include engineering design manuals; environmental handbooks tailored to specific technical or other user audiences; executive briefing documents for environmental policy and decision-makers; technical capsule reports on promising scientific and technical developments; environmental newsletters; national and regional seminars on selected environmental topics with seminar summary publications to reach an expanded user audience; and technical exhibits at appropriate national and international conferences and symposia.

In the near future, it is planned to amalgamate and streamline the current operating entities of the program within a single field component, the Environmental Research Information Center. This Center will be totally dedicated to the effective transfer of environmental scientific and technical information and outputs. With the establishment of this Center during early FY-1977, the historical mission of the effective but limited EPA Technology Transfer Program will be expanded from dealing strictly with environmental process control technology to the entire spectrum of ORD program activities such as environmental health and ecological effects research and environmental management techniques. This will further result in shifting the emphasis of the overall program from one of passive information dissemination to active transfer of results to specifically targeted user audiences.

Examples of specific information products which are planned for completion during FY-1977 are as follows:

Engineering Design Manuals and Handbooks --

- Land Treatment of Municipal Waste Water Treatment Process Effluents
- Alternatives for Treating Drinking Water
- Pollution Control for the Pulp and Paper Industry
- New Source Performance Standards and Related Air Pollution Control Technologies
- Control of Water and Solid Waste Effluents from the Power Industry
- Guidelines for Control of Pollutants in the Textile Industry

Executive Briefing Documents --

- Oil Shale Retort Test Results
- Techniques for Energy Conservation in 12 Industries
- Environmental Impact of Solar Heating Systems, Geothermal Energy Sources and Advanced Energy Systems

Technical Capsule Reports and Brochures --

- Recovery of Methane from Sanitary Landfills
- Control of Coke Processing Emissions
- Air Pollution Control in the Asbestos Industry
- Results of St. Louis Project to Burn Waste with Bituminous Coal
- Disinfection Techniques for Municipal Waste Water
- SWIRL Storm Water Control Project

- Composting of Sludge
- Land Treatment of Waste Water at Muskegon Coungy, Michigan
- Forest Harvest Residue Treatment, Reforestation and Protection of Environmental Quality

Technical Seminars --

- Small Waste Water Treatment Systems
- Sludge Treatment and Disposal Using Innovative Techniques
- Processing and Monitoring Technology for the Treatment of Drinking Water
- Municipal Pretreatment Guidelines for Industrial Effluents
- 208 Area Wide Planning Seminars on Institutional Regulations and Technical Aspects of point and nonpoint Sources of Pollution
- Combustion Modification Techniques for the Control of NOx Emissions and Particulates

Technical Seminar Summary Publications --

- Case Histories of Upgrading Municipal Wastewater Treatment Plants
- Upgrading Lagoons
- Cold Climate Treatment of Municipal Wastes
- Monitoring by Remote Sensing
- Pollution Control in the Fruit and Vegetable Industry
- Dairy Industry Pollution Control
- Pollution Control in the Mining Industry

In addition to the above projects, a pilot program will be initiated to evaluate the feasibility of utilizing the existing and substantial capabilities capabilities of our land grant university extension programs as an environmental information dissemination mechanism. If successful, this may prove to be an effective tool for transferring needed technology and other important technical information to local decision officials in smaller, rural communities.

In discussing the out-year plans for the Technical Information program, it is necessary to keep in mind that this is a level-of-effort program whose content and specific products are a direct result of three factors: The products and findings form the entire research and development program which becomes ready for the transfer of users; the relative priority of those products and the level of resources available to the program.

Historically, the principle emphasis in the active dissemination portion of the Technical Information program has been the transfer of proven water pollution control technology in the municipal and industrial program areas. Limited resources dictated little emphasis being placed on other technological areas such as water supply, air pollution control, nonpoint pollution management and the like. For this same reason, the thrust of the program had to center on national or, at best, regional audiences, even though the potential benefit of extending the program to the State and local level-funding, this situation will continue and it will be necessary to substantially reduce the current level of effort in the municipal and industrial water pollution areas in order to make resources available to get active transfer programs underway for several other critical areas of the total research and development program.

Over the next five years, the emphasis within the municipal waste area will shift from primarily transferring wastewater treatment technology to an increased emphasis on sludge handling, processing and disposal techniques; wastewater disinfection techniques; small flow treatment systems to improve pollution control in rural areas; improved energy conservation as it relates to wastewater treatment; and improved operation and maintenance methods for existing waste treatment plants. In the industrial area, emphasis will be given to energy conservation measures; technology for pretreatment of industrial wastes before discharging into municipal treatment systems; technological developments involving water reuse to assist the achievement of the zero discharge goal of the Federal Water Pollution Control Act; and the transfer of information to industrial users regarding current air pollution standards and the technology which is available to assure compliance with these standards. In the water supply area, emphasis will be given to methods to identify and measure contaminants in drinking water; to determine the health effect of contaminants; available and advanced methods of treating raw water; and techniques for protecting ground water sources of public water supplies from contamination. With respect to Areawide planning in response to Section 208 of the Federal Water Pollution Control Act, this program will be actively involved in the dissemination of improved methods for assessing, managing and controlling pollution from nonpoint sources; evaluating and planning for the combined impact of point and nonpoint sources; and advanced methods for land use planning. In the energy area, emphasis will be given to transfer of technologies for controlling, managing and monitoring air, water, and solid waste pollution associated with coal-fired or coal-derived synthetic fuel power plants; technological development in alternative sources of energy such as solid waste fuels, solar, geothermal and nuclear energy; and more effecient energy extraction and use processes. In the area of toxic and hazardous substances, this program will transfer a variety of operational outputs involving control system technology, monitoring and sampling techniques and methods and health and ecological data in the toxicity of various substances. Inherent in all the areas identified above, will be the continuing need to transfer to users, the latest available data on related health and ecological effects, and related monitoring sampling techniques, measurement methods, analytical procedures and quality assurance practices.

Potential Subprogram Growth Areas--

The air, water, and interdisciplinary technical support requirements of the Agency have not been fully measured because the program and regional offices, knowing the ORD resource limitations for technical support, generally submitted only those requirements which they could reasonably presume would be funded. Even so, vitally needed projects have slipped because they could not be funded until the next year. This has had an impact on the Agency's overall efficiency. By 1981 a modest growth option would permit support to be doubled. Whether the additional resources would be used to increase the number of new activities or to increase the volume of current activities would depend on program and regional office priorities. In either event, the growth option will permit the enhancement of the Agency's effectiveness in performing its mission by providing additional resources for the types of activities discussed under the base option.

SECTION III

CURRENT INTEREST MODULES

INTRODUCTION

In Section II, EPA's research program was shown to be composed of fourteen distinct subprograms, based upon generalized, long-term problem and functional areas. Real-world problems, however, rarely fit neatly into concise organizational structures. Normally, a coordinated effort, drawing upon resources and expertise from several different organizational groups, is required. This Section shows how such "interdisciplinary" issues are approached in the research program by citing several examples.

Examples of this concept are the integrated energy research and the quality asurance programs. Because of their size, level of priority and anticipated duration, they have been granted official program status. A similar example is the water supply research subprogram. All of these areas are discussed in Section II. To provide further examples of comprehensive approaches, this Section describes six more examples titled "Current Interest Modules." These modules address areas of current high public interest, which require resources and professional investigation from several of the fourteen subprograms. The current six issues are summarized as follows:

- Provide improved problem definitions and develop a range of practicable alternative control options for nonpoint sources of water pollution.
- Determine empirically if there is a relationship between the incidence of cancer and the concentration of chemicals in the Nation's drinking water supplies and ambient air.
- Determine whether special regulatory procedures are warranted for control of sulfate aerosols.
- Evaluate the potential environmental impacts of increased solar radiation due to reduction of stratospheric ozone.
- Provide the Agency with the scientific and technical basis to implement the Toxic Substances Control Act of 1976.

- Provide the Agency with scientific, technical and comprehensive research information as required by the Resource Conservation and Recovery Act of 1976.

Detailed descriptions of the modules follow.

NONPOINT SOURCES OF WATER POLLUTION

The objectives of this interdisciplinary research module are to develop methods for defining the contribution of water pollutants from dispersed sources relative to those discharged from point sources, and to develop alternative control strategies including cost-effectiveness data to permit selection of optimal strategies.

Background

It has been estimated by the Agency that possibly 50 percent or more of the nation's current water quality problems are caused by pollution of nonpoint-source (NPS) origin. NPS categories contributing substantial pollution are urban runoff, rural runoff, construction activities, waste residuals disposal, hydrologic modification, extractive industries, and forest management. Pollutants of greatest concern are sediment, pesticides, toxic metals, nutrients, pathogens, BOD, and dissolved solids. Other pollutants of concern include coarse and floatable solids and toxic organic compounds other than pesticides.

Until recently, water pollution abatement efforts in the U.S. have been directed primarily at continuously discharging point sources, with little attention given to nonpoint sources, which are generally intermittent and diffuse in nature. As greater levels of control are placed on point sources, their contribution to overall water quality problems becomes less significant relative to the contributions by nonpoint sources. Two things are becoming increasingly apparent. First, in many areas of the Nation, even with the application of best available treatment to all point sources of pollution, the PL 92-500 1983 water quality goals (or even lesser goals) cannot be attained because of pollution from nonpoint sources. Second, the propriety of continuing to direct pollution abatement efforts toward attainment of higher levels of point-source control is becoming more questionable. There are undoubtedly many areas of the country where the level of resources devoted to pollution abatement would be better utilized if devoted to nonpoint-source control, because the cost of reducing the load of a specific pollutant by an additional increment is lower for nonpoint than point sources.

The nonpoint-source problem is difficult to quantify for several reasons. One is the extreme diversity of the sources, both in their basic nature and their variation with location. Since nonpoint sources generally involve the interaction of man's use of the land with natural hydrologic processes (rainfall, snowmelt, etc.), the pollution contributions vary to the degree that man's activities, natural phenomena and the land vary. Moreover, nonpoint sources are intermittent and random in nature, making monitoring and evaluation difficult. A major portion of the pollutant discharge from land runoff may occur during but a few moments of a rainstorm or during but a few of the storm events occurring over the year. The magnitude of the pollution may depend on factors such as how long it has been since the previous storm or what man may have done on the land.

Development of appropriate control strategies requires methods and information to answer the following questions:

- What is the relative contribution of nonpoint sources to water quality degradation in a specific drainage area?
- Which are the significant contributing sources and which of these are due to man-induced rather than "natural" process?
- What is the relationship between effectiveness of controls and cost of controls?
- What is the relationship between effectiveness of control and anticipated water quality improvement benefits?
- How can the control measures be practically implemented within anticipated social, economic, legal and institutional constraints?

Interprogram Aspects

In order to develop a total solution to the NPS problem, research from many different subprograms is required:

- Methods and procedures to permit rapid detection of nonpoint sources and quantification of their pollution contributions and water quality impacts.
- Predictive techniques for estimating pollution contributions from the various NPS categories under a variety of climate and other conditions and their impacts on water quality under alternative NPS control strategies.
- Quality criteria applicable to the highly variable ambient water quality conditions produced by NPS discharges.
- Quantitative information on the costs and effectiveness of control/management practices for reducing NPS contributions.

- Delineation of various strategies for implementing a NPS control program in a watershed or river basin, with full consideration given to aspects of social acceptability.

- Methodology for assessing the costs and benefits of alternative levels of NPS control.

Current research efforts are being devoted primarily to characterization of the costs and effectiveness of various control/management techniques in reducing pollution contributions from nonirrigated and irrigated crop production, animal production, forest management practices, energy extraction activities, and urban runoff; and development and linking of NPS loading models to stream impact models to provide predictive techniques for estimating NPS pollution contributions and their water quality impacts under a variety of climatic conditions, physiographic features, and NPS control strategies.

The module also includes research on development of quality criteria applicable to NPS impacts on aquatic ecosystems; evaluation of the applications of remote sensing to the detection of nonpoint sources; and development of a methodology for evaluating alternative nonpoint pollution management strategies in urban and residential areas (with consideration of technical, economic, institutional, and social aspects).

Five-Year Plan

Serious deficiencies exist in all areas of the technical base needed. The tentative assignment of priorities is as follows:

First Priority--

- Provide an interim technical base for use by state and local planning agencies and EPA Regions in all areas of the country based on existing state of the art.

- Provide "wet weather" water quality criteria, i.e., criteria applicable to the time variable and probabilistic features of NPS's, with highest priority given to sediments, nutrients, DO, pathogens, dissolved solids, pesticides (and their toxic transformation products), and heavy metals prevalent in urban runoff.

- Provide the predictive and assessment methodologies required to identify and quantify NPS contributions (including deposition from the air), their impacts on water quality, and water quality improvements that would result from various controls.

- Provide information on the costs, effectiveness, and implementation feasibility of existing techniques for controlling urban runoff pollution.
- Provide information on benefits of NPS control.

Second Priority--

- Provide information on the costs, effectiveness, and implementation feasibility of existing techniques for controlling NPS pollution from agricultural activities, mining activities and timber harvesting.
- Provide methodology for evaluating the costs and benefits of alternative levels of NPS control applicable to urban runoff and agricultural activities.
- Provide methodologies for selecting the implementation strategy most appropriate for a given area or situation.

Third Priority--

- Provide information on the costs, effectiveness, and implementation feasibility of new techniques for controlling NPS pollution from urban runoff, agricultural practices, and mining activities.

Fourth Priority--

- Provide information on the costs, effectiveness, and implementation feasibility of existing techniques for minimizing surface water quality impacts from instream hydrologic modification.
- Provide more complete information on NPS contributions and effects of inorganic and organic toxic compounds and techniques for their control.

More detail on the planned outputs supporting the Nonpoint Source Research Module can be found in sections of the report on Ecological Processes and Effects, Transport and Fate of Pollutants, Renewable Resources, Waste Management, Environmental Management, Monitoring Techniques and Equipment Development, and Extraction and Processing Technology/Energy.

Effects of Resources on Scheduling

If this module suffered as much as a 10% reduction from its FY 1977 level, the first and second priority needs identified previously would not be met until near 1990. Since no systematic program to bring nonpoint sources under control throughout the Nation can be undertaken without the fulfillment of these needs, this would delay initiation of any serious effort by EPA to pursue the control of nonpoint source to the extent necessary to meet the 1983 goals of PL 92-500 until the mid 1980's or later.

If a level funding schedule were maintained, emphasis would be given to fulfilling the first priority research needs, although some attention would still be given to the second priority needs because of the longer lead time required.

Except for the interim technical base, few of the first priority needs would be met before 1979. The majority would be achieved by the end of FY 1985, however. Outputs associated with the second priority needs would be provided on a continuing basis, but complete characterization of existing control techniques would not be completed until beyond FY 1985. A modest effort would be given to the development of "wet weather" water quality criteria.

The collective impact of modest growth in the subprograms contributing to the Nonpoint Source Module would be to permit a modest increase in the level of research on most of the first, second, and third priority items. Most of the first and second priority needs would be met by the end of FY 1984, about one year earlier than with a level budget.

The recommended growth budget is summarized in Table 8 , and is considered the minimum program that will provide the essential technical base needed to implement defensible nationwide NPS program by the end of FY 1981. Additional resources would be used to meet all first and second priority needs by the end of FY 1981. Beginning in FY 1982, emphasis would shift to the third priority needs and still later to fourth priority needs.

ENVIRONMENTAL CARCINOGENS

The principal objectives for the environmental carcinogen program are to establish a monitoring program to profile and to characterize carcinogens in the environment; to develop retrospective and prospective external exposure models suitable for general population studies; and to assess the impact of exposure to environmental carcinogens upon the incidence of cancer in the general human population.

TABLE 8

NONPOINT SOURCE MODULE RECOMMENDED BUDGET
(million of dollars)

Subprogram	FY-77	FY-78	FY-79	FY-80	FY-81
Health Effects	0.0	0.0	0.1	0.1	0.0
Ecological Effects	0.4	2.4	3.0	2.5	1.0
Transport and Fate	1.3	2.0	3.0	3.5	3.1
Minerals, Proc. and Mfg. Industries	0.0	0.1	0.2	0.2	0.0
Waste Management	1.1	2.6	3.0	2.4	2.4
Renewable Resources	6.1	6.6	7.5	7.6	6.9
Environmental Management	0.3	0.8	1.4	1.4	1.2
Measurement, Techniques & Equipment Development	0.1	0.6	2.0	2.0	1.3
Energy Extraction Proc.	5.0	5.2	5.9	6.0	5.5
TOTAL	14.3	20.3	26.2	25.7	21.4

TABLE 9

CARCINOGEN MODULE RECOMMENDED BUDGET
(million of dollars)

Subprogram	FY-77	FY-78	FY-79	FY-80	FY-81
Health Effects	1.0	1.6	5.0	7.5	10.1
Monitoring Techniques Equipment Development		0.4	1.0	1.5	1.9
Water Supply	0.6	1.4	2.5	2.7	2.9
TOTAL	1.6	3.4	8.5	11.7	14.9

TABLE 10

SULFATES MODULE RECOMMENDED BUDGET
(million of dollars)

Subprogram	FY-77	FY-78	FY-79	FY-80	FY-81
Health Effects	6.1	7.5	7.5	6.8	6.8
Ecological Effects	0.9	1.4	1.4	1.4	1.4
Atmospheric Chemistry & Transport	4.5	4.9	5.0	4.8	4.4
Instrumentation and Measurement Methodology	1.2	1.7	1.6	1.3	1.3
TOTAL	12.7	15.5	15.5	14.3	13.9

Background

There is a growing awareness that environmental chemicals may be important contributors to the incidence of cancer in humans. This awareness, coupled with EPA's legislative responsibility for protecting public health from direct exposure to pollutants in the ambient environment and from pollutants reaching food sources, justifies an expansion of the Agency's research efforts to identify environmental chemicals which contribute to human carcinogenesis. There is conclusive evidence that exposure to a variety of chemical compounds in occupational environments has resulted in cancer of various types in humans. An ever larger number of chemical compounds known to be present in the environment have been shown to be carcinogenic in animal experiments. It has been postulated that human cancer in the general population may result from exposure to chemical agents in the ambient air, water, and food. If this hypothesis is true, then the public health benefit of identifying and controlling the responsible environmental agents is obvious.

Only limited information is available both on the distribution and levels of potential environmental carcinogens and on the extent to which the public health may be at risk from such agents. In FY 1976, EPA initiated an effort to develop a systematic research program for assessing the contribution of environmental carcinogens to the incidence of cancer in the general population. Through this program, EPA can make a major contribution to national research efforts on cancer because of its unique capability to characterize and monitor environmental exposures. As an integral component, the program will consolidate and coordinate the many data bases which currently exist in other agencies. A coordinated effort among pertinent Federal, state and Regional Agencies will be required in order to avoid duplication and to take full advantage of available expertise and resources.

Interprogram Aspects

The nature and scope of the environmental carcinogen problem is such that it spans the missions and responsiblities of a number of governmental agencies, the private sector, and the environmental research program. An extensive cancer research effort is currently underway nationally. Much of this effort falls within the scope of the program approach outlined below, and hence, will provide essential information. EPA's program is designed to fill major gaps in our knowledge of environmental carcinogenesis for the specific purpose of establishing the data base needed for fulfillment of regulatory responsibilities.

Accomplishment of the plan will require a closely integrated long-range program involving environmental monitoring, epidemiological studies, biological laboratory experiments, and an extensive vital statistic repository. The approach outlined below is described in broad general terms to provide a framework for a long-term effort. The activities will require much more detailed planning and coordination prior to implementation.

Each of the major research areas is progressing concurrently; but they are clearly interdependent as demonstrated in Figure 5. For example, there will be a point in time at which the retrospective epidemiological study cannot proceed without the retrospective exposure model as a basic input. The retrospective exposure model, in turn, is dependent upon environmental monitoring data, emission and source inventories, climatic data, and so forth.

Five-Year Plan

Retrospective studies will determine whether increased cancer rates are causally related to chemical agents in the air and water. Areas will be identified in which current exposure to known or suspected chemical carcinogens is high, and the impact of such exposure will be assessed and compared to areas of low exposure.

Development of Improved Methodology--

An important area of development to be expanded and coordinated with other agencies involves methodology in monitoring and biological testing. Areas of need in this category include:

- Development of additional monitoring techniques and improvement of current and emerging techniques for application to an extensive monitoring program for carcinogens. These techniques should not only be highly sensitive and specific but also inexpensive, rapid, and easy to use.

- Improved methods to test for carcinogenicity of suspect agents that reflect internal stress or load as well as external exposure.

- Development of methods to identify and characterive population exposure patterns.

Historical Data Assessment Selection of Study Areas--

The primary criteria for the initial selection of study areas will be high cancer mortality rates (relative to the national average), cancer types, and high population exposure to known or suspected carcinogens. Final selection of populations will involve a careful examination of demographic data. Environmental monitoring sites will include, but not necessarily be limited to, the population study areas. Additional monitoring may be conducted in potentially high exposure areas. Other potential study areas might include those in which the environmental pollution can be attributed to a single major source. Final selection of study areas will be made only after careful consideration of all significant factors, and in consultation with the National Cancer Institute and other interested agencies and advisory groups.

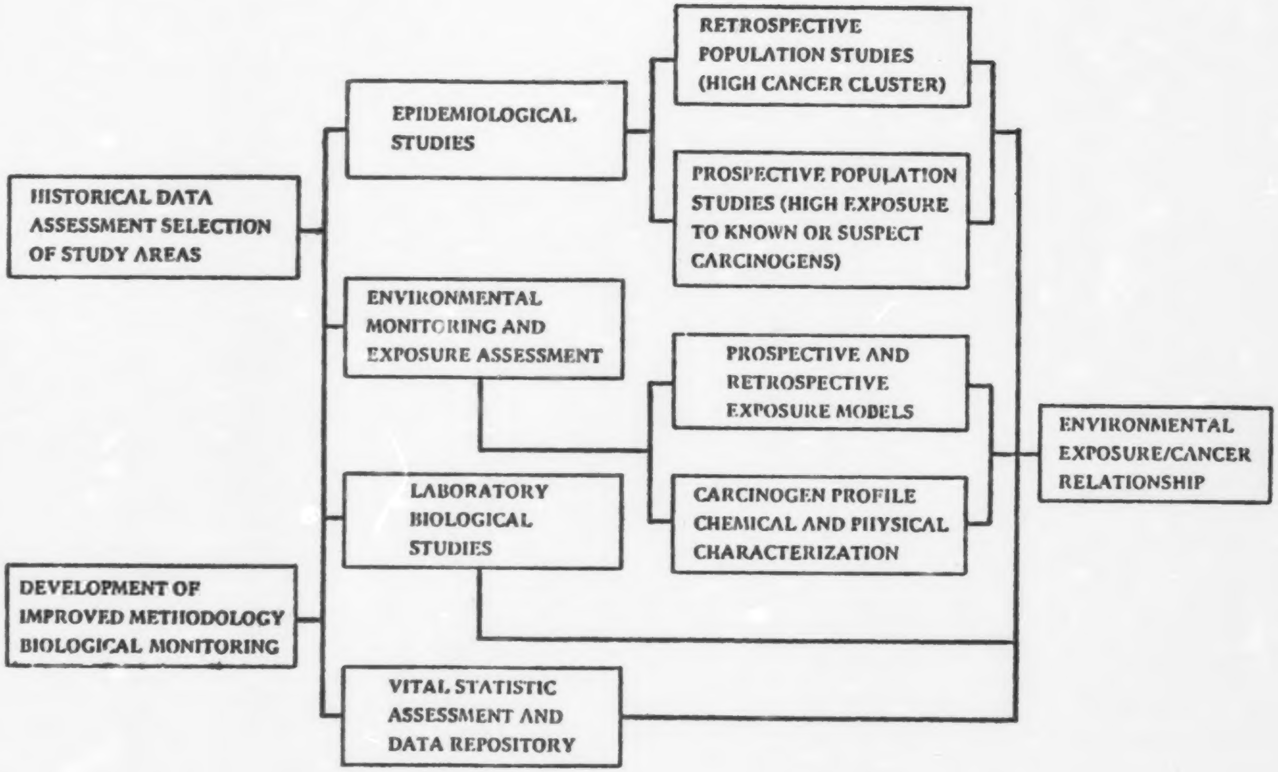
HISTORICAL DATA ASSESSMENT SELECTION OF STUDY AREAS
DEVELOPMENT OF IMPROVED METHODOLOGY BIOLOGICAL MONITORING
EPIDEMIOLOGICAL STUDIES
ENVIRONMENTAL MONITORING AND EXPOSURE ASSESSMENT
LABORATORY BIOLOGICAL STUDIES
VITAL STATISTIC ASSESSMENT AND DATA REPOSITORY
RETROSPECTIVE POPULATION STUDIES (HIGH CANCER CLUSTER)
PROSPECTIVE POPULATION STUDIES (HIGH EXPOSURE TO KNOWN OR SUSPECT CARCINOGENS)
PROSPECTIVE AND RETROSPECTIVE EXPOSURE MODELS
CARCINOGEN PROFILE CHEMICAL AND PHYSICAL CHARACTERIZATION
ENVIRONMENTAL EXPOSURE/CANCER RELATIONSHIP

Figure 5. Environmental Carcinogen Research Module Plan

Environmental Monitoring and Exposure Assessment--

The environmental monitoring program will provide a profile of chemical carcinogens in the atmosphere and different water supplies in selected areas. This will include the identification of chemical compounds or complexes, their respective concentrations, and their physical state. These data will provide the basis for establishing current external exposure levels, as well as the retrospective and prospective exposure models.

The monitoring program will have six specific objectives: (1) to identify known or suspect carcinogens (as defined by animal studies in the atmosphere and drinking water supplies; (2) to measure concentration gradients in the atmosphere and between different drinking water supplies (these data will serve as the basis for establishing external exposure patterns); (3) to conduct specific measurement programs in support of epidemiological studies; (4) to prepare reliable source and emission inventories; (5) to develop retrospective and prospective exposure models; and (6) to collect material samples for biological studies. A rigorous quality assurance program will be implemented in all phases of monitoring activities to ensure reliable and comparable results.

Epidemiological Studies--

When carefully planned and properly executed, epidemiology can make a major contribution to our understanding of the impact of chemical carcinogens on human populations. It provides the oppurtunity to look at agent and host interaction in the real world context. The two classical epidemiological approaches should be employed in this endeavor: retrospective and prospective.

In the first approach, a cluster of cancer cases of a specific type would be identified for study to determine factors that may be causing the cancer. The first phase of such a study is exploratory and retrospective in nature. It involves studying such characteristics as occupational history, residence history, familial aggregation and exposure to a broad spectrum of chemical and biological agents. An important part of this characterization will be retrospective and prospective exposure to chemical agents in air and water. Because most cancers have a long latency period, it is essential that the characterization of chemical and biological agents historically cover at least a twenty-five year period.

However, it is also important to determine the number of these agents which are still currently sources of exposure. The differences in the characteristics of the cancer cases compared to the non-cancer cases should lead to important clues which will permit the formulation of a test hypothesis. If the hypothesis involves exposure to a chemical carcinogen as a factor of causation, then the next phase of study will be the testing of the hypothesis. The first step in this phase of study will be to determine the prevalence of cancer in an exposed versus a non-exposed population whose time of exposure permits the expression of a latency period. The next step will necessitate the identification of a statistically determined cohort of individuals presently exposed to the agent or agents, and an appropriately matched non-exposed control group which will be traced through time to determine the incidence of the cancer in the two groups. Although cancer is a major cause of death, its occurrence is statistically small, therefore, the studies must involve large populations.

In the second epidemiologic approach, a population exposed to known carcinogens should be studied to determine the effect of such exposure on that population over time. Characterization of retrospective and prospective exposure models is also an integral part of this approach.

Laboratory Biological Studies--

Extensive laboratory studies currently are underway in a number of agencies including EPA which involve biological screening, metabolic pathways and target organs, response mechanisms, and dose response. Areas of primary importance to EPA which require further research include identification of most sensitive biological responses and indicators suitable for use in general population studies; dose response relationships for realistic exposure conditions (levels to which the general population is normally exposed) for single and multiple carcinogens; and improved methodology for extrapolating from animal experiments to humans. Detailed programs are to be formulated through interagency groups and stipulated in Interagency Agreements.

Vital Statistics Assessment and Data Repository--

A well organized program in this area could make a substantial contribution to the overall cancer assessment program. Long-term records properly formatted will provide the basis for establishing trends in cancer statistics, and hence the assessment of implemented control strategies. A categorical program in this area should be formulated by an interagency group comprised of representatives from EPA, DHEW, DOC, and other interested Agencies.

Related Studies--

For the sake of brevity, only those programs intimately involved with the module have been discussed herein. However, there are many more related studies which may produce results useful to the environmental carcinogen program. In general, these are pollutant-specific programs which will supply useful data if those pollutants are also present in the high cancer areas. Other related studies include development of multi-pollutant measurement methods, exposure assessment and case-control studies near selected industries, and carcinogens assay systems using microbiological and mammalian cell culture techniques.

These programs and those in other agencies will be thoroughly examined to locate applicable results and data. Interagency Agreements will be used to the maximum extent possible to assure a cost-effective program.

Interprogram Funding

Although for adminstrative purposes, funds are allocated to only the Health Effects and Water Supply Subprograms, about one eighth of the total effort is performed by the Monitoring Techniques and Equipment Development Subprogram, through an interprogram agreement. Budgets for a five-year modest growth program are presented in Table 9.

SULFATES

The primary objective of this research plan is to provide the scientific basis needed to determine whether regulatory action on the selected sulfates is warranted. If regulatory action should be required, the research plan must also provide the scientific bases for setting standards and developing control strategies in the required time frames. The secondary objective is to identify other sulfate species that are both biologically significant and commonly found in the atmosphere.

Background

Although atmospheric suspended sulfates have been identified as a potential environmental problem for many years, an increase in the use of sulfur-containing fuels has focused added attention on possible adverse effects of particulate sulfates. Data regarding causal relationships, biological mechanisms, and dose-response relationships are limited, particularly at concentrations to which the general population is normally exposed.

Total sulfur in the atmosphere is distributed in a wide variety of gaseous and particulate, inorganic and organic compounds or complexes. The traditional definition of sulfates has been an operational one: material collected on a high-volume sampler filter and analyzed as water soluble sulfates. This method cannot distinguish between the various sulfur compounds that may be present, nor can it distinguish between the particle sizes. Thus, the composition of the sulfate aerosol has not been characterized. Such characterization is important because chemical structure, acidity and particle size of sulfates appear to affect the biological response.

Suspended sulfates are generally submicron secondary aerosols, principally derived from atmospheric reactions of gaseous precursors. However, the observed sulfate concentrations are not always highly correlated with SO_2 concentrations. This suggests that factors other than local SO_2 concentrations, such as long-range transport and transformation of primary SO_2 emissions, control the rate of sulfate formation. These factors are critical relative to developing control strategies and determining population exposure patterns.

Interprogram Aspects

Because of the lack of information in the areas discussed above, research has in the past few years concentrated on identifying through toxicological studies, which components/compounds and what size particles are biologically active, developing instrumentation and measurement methodology to specifically identify particulate species, and developing the scientific data needed to relate emissions to ambient air concentrations of sulfates.

Currently, four different subprograms are participating in the sulfates research module: Health Effects, Ecological Effects, Transport and Fate of Pollutants, and Monitoring Techniques and Equipment Development.

Control technology is commercially available for controlling sulfate precursors such as SO_2 and particulates. Many major emission sources have already been equipped with desulfurization processes. Similarly, particulate emissions can be controlled with available technology, with removal efficiencies in excess of 99% often achievable at reasonable cost.

Other technology is under development that will reduce total SO_2 emissions, especially in future years. In addition, technology is being evaluated for smaller sources including smaller boilers and industrial processes. The EPA and ERDA are developing techniques for the removal of sulfur from fuel prior to combustion. Technologies under development address methods such as physical and chemical coal cleaning, liquified coal, and clean synthetic fuels. It is not known with certainty if these demonstrated and potential abilities will effectively control sulfate precursors. The current technology RD&D program can be extended to achieve increased SO_2 control, should such a need be identified and mandated. Therefore, control technology development remains in the base program, until such time as the regulatory decision is made.

Five-year Plan

The objectives of health effects research in the next few years are to assess the impact upon public health resulting from exposure to several specific sulfate compounds in the ambient atmosphere, and to determine whether sulfate concentration as traditionally expressed is an adequate parameter. Species chosen for emphasis were based on toxicological studies and prevalence in the atmosphere. Accomplishment of these objectives will require a closely integrated approach involving animal toxicology, controlled human exposure studies, epidemiology, measurement methodology and instrumentation, and atmospheric chemistry and transport research. Results of this research will provide the scientific basis for agency decisions in 1980-81 on whether regulatory action is required.

Toxicological studies in FY 78 - FY 79 will focus on developing health indicators and dose-response data for the selected species, and will continue screening other sulfur oxide compounds to determine their degree of biological activity. Increased efforts in FY 78 - FY 79 will provide for a new epidemiological study targeted on specific sulfate species, and for the expansion of controlled human exposure studies on various sulfates. Controlled human exposure studies will be initiated, with normal subjects being exposed to low concentrations.

Ecological effects research will provide the basis for secondary standards, should such regulatory action be required. The principal problem areas are plant damage and acid precipitation. Principal products will be a dose-response relationship for plant damage (acute and chronic) from sulfate aerosols, and a delineation of the effects of acid precipitation on soils, crops, and aquatic systems.

The current effort on effects of sulfur oxides on terrestrial ecosystems will be expanded to initiate a long-term study the extent of damage to the environment from acid precipitation. Sulfates are suspected to play a major role in the formation of acid precipitation, and early evidence indicates that acid rain is a problem potentially affecting large areas of the Nation.

Transport and Fate Subprogram research will develop experimental data and empirical models to relate sulfur oxide emissions to ambient air concentrations of sulfates. Primary factors involved include emissions, transformation mechanisms and rates, size and chemical composition, and removal mechanisms.

If a decision is made in 1980-81 that regulatory action is required for certain sulfates, a scientific basis must be available for relating the ambient concentrations to emissions of precursors. A modest acceleration of research on transport and fate is necessary to develop this information in the desired time frame. This increase will allow for estimation of the contribution of natural sources to the atmospheric sulfur burden, studies of the effects of sulfates on visibility reduction, and association of acid precipitation effects with meteorological parameters. Current work on regional scale (100 km) transport and transformation will be redirected into a number of intersive field studies on a larger scale (100-1000 km).

The Monitoring Techniques and Equipment Development Subprogram will measure total sulfur, trace elements, sulfuric acid, sulfate ion, ammonium ion, size distribution, gaseous sulfur, hydrogen sulfide, mercaptans, and organic sulfides in order to determine the various cations associated with the sulfate anion. The methodology and instrumentation for these analyses are now under development. A number of the techniques can now be used in a laboratory situation with highly qualified personnel; however, they are not suited for general field use, and have not been thoroughly evaluated and standardized. A modest expansion of effort is required in FY 1978 - FY 1981 to accelerate availability of research instrumentation for health and atmospheric field studies, and for standardization of potential monitoring instruments/methods.

Interprogram Funding

Resource summaries for each subprogram are given in Table 10.

EFFECTS OF INCREASED ULTRAVIOLET RADIATION

The objective of this research effort is to assess the significance of the environmental impact of increased ultraviolet radiation resulting from the discharge of hydrocarbons into the stratosphere. Like the others, this module is interdisciplinary, but because of existing research and expertise, the research effort is composed of the coordinated contributions of several Federal agencies as opposed to several subprograms in EPA's research and development program.

Background

In 1972 the Federal government initiated the Climatic Impact Assessment Program (CIAP) in response to questions associated with the use of supersonic transports (SST). The major concern of CIAP was to project the impact on stratospheric composition of the injection of SST exhaust. Emphasis was placed on stratospheric ozone reduction through chemical reactions. Ozone in the stratosphere aids in the absorption of harmful ultraviolet solar radiation.

A large portion of the CIAP effort was stratospheric chemistry, with relatively little effort directed toward the environmental effects. The possibility of marked environmental impact was indicated, but uncertainties associated with results were large, and the need for more research was obvious. The CIAP research was terminated in 1974 and results were published in 1975.

In 1974, independent of CIAP, research was reported indicating the possibility of significant stratospheric ozone reduction as a result of the photodissociation of chlorofluoromethanes (CFM). The CFM's are emitted to the atmosphere on a relatively large scale as a result of their use as aerosol propellants and refrigerants.

In 1975, the Committee on the Inadvertant Modification of the Stratosphere (IMOS) addressed the issue of stratospheric ozone reduction and subsequent ultraviolet radiation increase resulting from CFM emissions. A subcommittee report entitled "Biological and Climate Effects Research" (BACER) recommended an interagency research effort to assess the environmental impact of the continued use of CFM's. This proposed program included short-term and long-term elements.

Because EPA has authority to regulate emissions to the environment, the Agency was selected to manage the short-term BACER program. The Office of Research and Development accepted this responsibility and subsequently established interagency technical and policy groups.

The BACER technical and policy groups developed a research plan responding to the short-term BACER program. This program is designed to support regulatory decisions anticipated for late 1977. Consequently, all research tasks within the short-term program are designed to provide research results by December 1977.

Projected effects on the biosphere of enhanced UV radiation include increased incidence of skin cancer in humans, deleterious effect on food and fiber crop yield, subsequent impact on animal husbandry, impact on natural and managed ecosystems, impact on commercial and recreational fishing, and effects on climate. Preliminary research shows a latitudinal variation of the incidence of skin cancer in humans, correlatable with the natural variations of ultraviolet radiation with changes in latitude on the earth's surface. Additional laboratory studies, field studies and epidemiological studies are needed in order to understand this relationship adequately.

With respect to non-human biological effects, experiments have been performed on biological systems simulating approximately 40% ultraviolet radiation enhancement. These experiments resulted in serious deleterious effects. Recent research indicates that continued CFM emissions could eventually (approximately 50 years) result in a stratospheric ozone reduction of between 2 and 20%. Present estimates of ultraviolet increases are within the range of 4 to 40%. Experiments with economically important agricultural crops and ornamental indicator plants have also shown marked deleterious effects by elevated exposures. The number of species studied and the degree of damage is a clear indication of the need for further research. Research on effects of radiation level increases in the range of 5-40% are needed.

The effects of ultraviolet radiation (UV) on economically important marine species have not been investigated. At present, the rate of penetration of UV into water is not known with any degree of certainty. There are indications that UV radiation may influence eye cancer in cattle, a major cause of slaughter house condemnation.

Too little is known to predict the effects of UV on natural systems. However, there is evidence of sensitivity of certain forest species (Engleman spruce). The effects on insects and pathogens is unknown. Also, the effect of increased UV on phytoplankton, a major element in the food web, is for the most part unknown. Only general information of a qualitative nature on the effects of climate change on the biosphere is available. Purturbation of the earth's energy balance resulting from increased UV may effect climate which will effect crop yields.

Interprogram Aspects

Many different scientific disciplines are necessary to assess the potential total environmental impact of increased solar ultraviolet radiation. The list is lead by radiation measurement scientists, followed by experts in the many different types of environmental effects, and social scientists for assessing consequent effects on the Nation's economy.

Because of the highly specialized nature of the problem, little expertise existed within EPA for conducting the requisite research. Expertise did exist within the Federal establishment, however, in agencies having missions of a more basic nature than EPA. Thus, the module is implemented primarily through interagency agreements with the Departments of Agriculture, Commerce, and Health, Education, Welfare, as well as the National Aeronautics and Space Administration and the National Science Foundation.

Short-Term Plan

In the early part of fiscal year 1978, outputs from the following previously funded projects are expected:

Instrumentation --

- Instrumentation consultation by Task Group
- Standards for sources
  - Establish the argon mini-arc as standard of spectral irradiance.
  - Modify design of arc to improve its stability and maximize UV-B output.
  - Intercompare the argon arc spectral irradiance scale with other NBS scales.
- Standards for UV-Instruments

  Laser characterization of narrow-band radiometers and Si photodiodes:

  - Extend capability of present cw dye laser to UV-B spectral region by extra-cavity frequency doubling.
  - Characterize three narrow-band radiometers (peak responses at approximately 290, 300 and 310 nm) for the measurement of UV-B irradiance sources.
  - Characterize three unfiltered silicon photodiodes at several wavelengths from 229 nm to 364 nm.

  or

  Establish a facility for the calibration of UV-B instrumentation by using the well-characterized output of the synchrotron radiation from the NBS storage ring.

- To construct a portable spectroradiometer for UV measurements in the field. To construct lab spectroradiometer to serve as standard for calibrating detectors and sources.

- To develop UV sources for use in greenhouses and growth chambers.

Climate and Monitoring--

- Climate modeling of regional differences and correlation of regional climate statistics and impact.

- Climate workshop summarizing current information and definition of research needs.

- Data reduction and analysis of satellite observations (WIMBUS/BOV) (6 years)

- Support of UV-B continuous spectrodiometric data collection station.

- Support continuation of on-going monitoring at several field location of R-B meter, Smithsonian filter wheel radiometer (Tallahassee) and modified Dobson spectrophotometer (Boulder) (FY-76-15K/FY-77-15K).

- Operation of R-B meter network. Obtaining two or more calibrating units. Funds needed to operate, repair, and maintain network and for operation of the computer capability aspect if installed.

Biological Effects--

- Whole plant response (growth and development)

- Photosynthesis

- Membranes/respiration

- Tillering and seed quality in wheat, fiber quality in cotton

- Food reserve mobility in seedlings

- Sexual reproduction of plants

- Cellular/structural changes

- Fungus Pathogens/Plant Response

- Core Program Management

- Broad band UV-B on crop production. (Combine with project below)

- Impact of Solar UV-B on Crop Canopies

- UV-B Effects on photosynthesis and plant growth

- High altitude studies of natural/supplemental/deletion of UV-B on vegetables

- Stability of agricultural chemicals under increased ultraviolet radiation

- Effects of UV-B sensitivity of higher plants (Provides additional support for ongoing projects already suppored by NASA and NSF)

- UV-B radiation on growth and development of high elevation forest tree seedlings

- Effects of UV-B on N-Fixation by blue-green algae

- Effect of UV-B radiation at the agricultural ecosystem level; skin cancer of livestock

- Effects of UV-B on insect survival, diapause, and interaction with plants

- Extramural program support

- Penetration of UV-B natural waters

- Sensitivity of eggs and larvae of commercially important marine organisms

- The effect of UV-B irradiation on surface-living organisms and ecosystems of puget sound

- UV tolerance of aquatic organisms and ecosystems

Human Health Effects--

- Non-melanoma incidence studies at several SEER sites to supplement four TNCS site (Objective 1)

- Analysis of HANES data on non-melanoma (Objective 1)

- Analysis of unpublished melanoma incidence data for baseline trend (Objective 1)

- Follow-up studies on non-melanoma patients in TNCS and HANES studies to determine exposure habits, skin types, etc. (Objective 2)

- Follow-up studies on melanoma patients for exposure habits, skin

Economics--

- Economic evaluation of environmental impacts

Long-term Plan

The short-term BACER program is designed to provide information which can be generated within a short time for a possible Agency decision to regulate fluorocarbons.

It is generally recognized in the scientific community that most of the basic uncertainties on effects of stratospheric ozone reduction cannot be significantly reduced by a short-term effort. In recognition of this and the need to consider the effects of all potentially significant modifications to the stratosphere, IMOS is developing an FY 78 interagency budget for a long-term BACER program.

Because of the strong basic research thrust of this long-term effort, and the lack of immediate regulatory application, EPA is not necessarily the appropriate lead Agency. However, EPA will continue to actively participate on the IMOS Committee.

CONTROL OF TOXIC SUBSTANCES

The objective of this research module is to provide the Agency with the scientific and technical information to implement the Toxic Substances Control Act of 1976. The following material presents coordinated efforts that could be undertaken by the various research subprograms. As indicated in Section IV, this effort would be conducted in close coordination with relevant groups within the Department of Health, Education and Welfare.

Background

The Toxic Substances Control Act requires the Agency to restrict the use and marketing of particular chemicals and manufactured products to protect the environment. Specifically, decisions must be made on restrictions on the marketing or handling procedures of materials to lessen the risk from their release to the environment. In addition, analytical methods must be developed and validated to support the regulatory program.

Industrial firms in the United States produce thousands of chemicals for domestic, commercial, or industrial consumption almost all of which end up in the air, water, or land. Thousands of by-products and waste products are introduced to the environment in wastewater streams, air emissions, or by land disposal. In addition, each of these chemicals can be biologically or chemically converted in the environment to other compounds.

Although little is known about most of these compounds, several have been demonstrated to be toxic to man and his environment. Among these toxic substances are PCBs, various pesticides, heavy metals, and many aromatic hydrocarbons. · Based on experience to date, it is probable that many other toxic substances are continuously being introduced or formed in the environment.

The most pressing need for research on toxics is to define the magnitude of the problem. Information must be developed on which substances are harmful and in what concentrations. Modes of discharge of harmful substances to the environment, their transport and fate, and their human health and ecological effects must be determined. This information forms the basis for a logical, rational, consistent, and defensible regulatory policy and meet the requirements of legislative mandates.

Several regulatory approaches can be formulated to control the problem of toxic substances. The traditional approach is to reduce or eliminate discharges by requiring use of appropriate effluent treatment technologies. However, similar results can be achieved in many cases by production process modifications. Another approach is to restrict the use of chemicals which may be harmful. Alternatively, regulations can be formulated to control the formation of toxic substances from other, more innocuous chemicals. The choice among regulatory approaches should be based on sound relevant research information.

Interprogram Aspects

Traditionally, research resources have been used to advance the state-of-the-art and to develop new techniques for detecting pollutants in general or their biological effects, developing new concepts for controlling their discharge, and developing techniques for assessing the environmental reactions of pollutants. These research efforts typically involve only a single discipline and are essentially directed by the judgments of an individual researcher or research groups based upon understanding of knowledge gaps in the areas of concern.

But the state of art with respect to specific toxic substances detection, health and ecological effects assessment and control technology has not reached the stage of maturity where individual researchers or groups thereof can direct or focus their efforts. In the next few years the major research thrust must create a knowledge perspective base so that research communities at large can focus future efforts on the most urgent toxic substance problems.

The research thrust will entail activities designed to yield preliminary information on the likelihood of effects of toxic substances on environmental and human populations. It must examine persistence or concentration of these substances in the environment, and their susceptibility to control by previously demonstrated technology. These research activities involve the establishment of a set of screening tests for probable biological effects and fate in the environment and an evaluation of the effectiveness of available control technology or production process modifications in reducing toxic emissions.

Large numbers of toxic substances are found in all environmental media, and in general transfer from one medium to another as they move through the environment. For this reason, toxic substances research must be multi-media in nature. It must also be interdisciplinary with ecologists and toxicologists needed to understand health and ecological effects; chemists, biochemists, meteorologists, and hydrologists needed to understand transport and fate phenomena; and engineers and economists needed to develop practicable control technologies or strategies. Through implementation of a synchronized research program, the problems of defining, understanding, and controlling toxic substances can be bounded.

Because of the magnitude of the problem, it would be impractical to assess and control each toxic substance individually. Rather the first step of the research program must be to define ways of grouping substances so that knowledge which is developed and controls which are applied are relevant to whole classes of compounds. If a series of tests can be developed such that the problem is logically reduced to smaller and more manageable size, the critical first step will have been achieved.

The following plan includes the coordinated efforts of five subprograms: Health Effects, Ecological Effects, Transport and Fate, Monitoring Techniques and Equipment Development, and Minerals, Processing and Manufacturing Industries.

Five-Year Plan

Health Effects--

New and more sensitive bio-effect indicators as well as methodologies for coherent evaluation of possible multi-level impacts in ecosystems are needed. The development of screening tests for certain types of genotoxic activity (e.g., mutagenesis, neoplastic transformation) has progressed rapidly in recent years. However, this development has been paced by gaps in fundamental knowledge associated with biological, chemical, and biochemical mechanisms. Research on generic in-vivo and in-vitro chemical-tissue interaction and the potential correlation of biological activity of toxic substances with their chemical structures is essential to improve the reliability of predictive screening techniques and to increase our capability to extrapolate from in-vitro test systems.

Program plans involve exploitation of the potential utility of in-vitro test systems in localizing metabolically active target organs in animals and in identifying animals and plants capable of metabolic conversion in the ecosystems. Such studies will contribute directly to the "validation" of system results and ultimate development of both structure activity and toxic unit techniques. Studies on the sequence of events that lead to biochemical alterations at the tissue, cellular, and subcellular levels will provide directly useful data for health and ecological risk assessment as part of comprehensive environmental analysis. Thus it will be possible to extrapolate the nature of chronic health effects on the basis of even subacute tests on a more valid basis.

Clinical studies of human subjects under carefully controlled conditions will be extremely important and will be intended to validate human-animal correlations. The development of methods for the prediction of substances' effects on human health will be the ultimate goal of concentration-response studies performed with selected populations exposed in the past to substances under investigation. Epidemiologists will use bio-chemical, immunological, and cytological indicators which are responsive to the substance in question at ambient concentrations. Much of the data on human exposure effects will come from occupational situations.

Ecological Effects --

Evaluation of counterpart ecological tests for chronic effects prediction will also be developed and validated. The monitoring of reproductive capacity, effects of diet, organogenesis, growth maturation, and postnatal development in broad classes of animal species will offer multiple opportunities to cross-correlate environmental effects of toxic substances and broad groupings thereof.

Transport and Fate--

Supporting research to document and analyze various fate and transport processes is underway for a few toxic substances within the base program. However, the science associated with determining or predicting the transport, distribution, and persistence of the multiplicity of toxic substances and groups thereof in air, terrestrial, or aquatic environments is new and complex. Problems evolve from the presence of these substances in the environment as mixtures or in a variety of forms.

Methods for obtaining and evaluating some of the required data are inadequate or lacking. Many of the existing methods are costly, technologically intricate, and involve long time periods for execution. This program will attempt to evolve and evaluate less complex methods. These short-term screening methods will be designed to establish the presumption of environmental persistence for various classes of substances.

Thus, the objectives of the fate and transport research program will be as follows:

- Provide better scientific understanding of fate and transport processes and interactions,
- Develop improved predictive methods,
- Develop more effective quick, effective, and inexpensive screening techniques,
- Develop methods to group materials according to their environmental behavior to allow greater numbers of materials to be handled efficiently, and
- Develop conceptual procedures or models to relate various treatment and control strategies to safe or acceptable environmental concentrations.

Monitoring Techniques and Equipment Development--

The detection and quantitative measurement of toxic substances in the environment and in effluent streams provides the data for use in health/ecological and fate/transport studies. However, for many toxics the analytical methods and instruments do not exist for use in gathering needed data.

In the past, it has been necessary to separate organic chemicals from streams being monitored in order to identify and measure them. Furthermore, because of limitations of available detection methods, concentration of streams prior to analysis has been required. Separation and concentration techniques may be needed for categories of substances. Currently, the best approach to resolution of this problem appears to be the use of accumulators through which large volumes of air or water can be passed, depositing the organic materials. Selective accumulators and fractionation by selected elutrients offer possibilities for preliminary compounds which are volatile enough to pass through a gas chromatograph present relatively few problems of final separation; however, they comprise only 10-30 percent of the usual mass of organic material in wastewater. Separation techniques for the non-volatile categories of compounds need refinement. Separation devices are needed to couple with identifying detectors so that cost-effective identification and measurement of non-volatile categories of organic compounds may be analyzed.

Spectra-generating devices, such as mass spectrometers and infrared spectrometers are adequate for volatile substances, but non-volatiles cannot be measured using conventional mass spectrometry. Atmospheric pressure ionization mass spectrometry and Raman spectroscopy should be developed for application to this problem.

Identification of classes of substances from their mass spectra has been made relatively inexpensive through development of computerized spectra matching programs. Refined search programs are needed to make tentative identifications more reliable, Spectral files need expansion and validation.

Identification of substances for which spectra do not exist in computer files involves considerable manual interpretation by analysts. This tedious and expensive process will be shortened and rendered more reliable and economical as standard protocols are developed for identifying them, and computer programs are developed for assisting in data interpretation.

Attempts have been made to synchronize analysis for substances in drinking water with studies of their health effects. Most of the epidemiology studies in the past considered only one substance at a time. Effects of substances not measured may have clouded the observation of the more important epidemiological relationships. Therefore, until the key trace elements are indicated, they must be considered as a broad class and practical consideration must be given to groups of substances in health studies. Because of the number of chemical substances of concern in assessing environmental health effects, it is not useful to measure them by single-element methods. Spark source mass spectometry (SSMS) is the only instrument capable of measuring simultaneously up to 82 elements at concentrations as low as 1 ug/l. However, it is expensive, slow, and relatively imprecise.

Two multi-element techniques, X-ray fluorescence spectrometry and indictively coupled plasma emission spectrography, now being studied in this program element, may overcome most shortcomings of SSMS. However, neither method possesses the uniform detection levels for all elements that SSMS exhibits, and neither covers as broad a spectrum of elements.

A third technique, argon plasma source mass spectrometry may ultimately be the best technique currently under development. More research also is needed to evaluate matrix effects in environmental samples.

Another area of needed measurement development is chemical speciation. Even after substances are detected in effluents, their chemical form should be characterized. Past research indicates that health effects depend on oxidation state, degree of ionization or complexation, and other characteristics of the substances. In the future there will be a growing interdependence between the chemical analyst and the health effects researcher in evaluating chemical species - health effects relationships.

Minerals, Processing and Manufacturing Industries--

There is a need for categorization of toxic substance effluents by source and development and demonstration of control technologies that can remove or control broad categories of effluents to air and water. The economic practicability of technologies such as reverse osmosis and carbon absorption have not been demonstrated, nor have the applicability of the technologies for control of specific emissions or discharges been demonstrated on a plant-wide basis.

Four steps will be involved in this control technology program element. The first will be determination of theoretical limits for effectiveness of control technologies. Second, laboratory-scale control units will be constructed and tested to determine if the expected effectiveness is achievable and to study the effect of varying operating parameters. The third step will be to scale-up the units to pilot scale, to conduct extensive tests to determine problem areas, and to characterize each process for effluent controllability effectiveness. Engineering equations will be developed to characterize the operation of the unit and to design full-scale systems.

Finally, a demonstration unit for the control technology will be constructed for processes that have been proven viable and an indepth characterization program will be implemented. Knowledge from this demonstration effort will allow commercial equipment manufacturers to design and construct their own units for use by industry so that the Agency can implement toxics BATEA enforcement for aqueous effluents and NSPS for air emissions.

RESOURCE CONSERVATION AND RECOVERY

The objective of this module is to expand the base research program in solid and hazardous waste management and resource recovery. Because of the tight implementation schedule in the new hazardous waste regulatory program, the plan provides special emphasis in that area.

Background

The new solid waste disposal legislation provides for new hazardous waste regulatory authority, and expands EPA responsibilities for standards setting, guideline issuance and promulgation of regulations. Additional technological support for the expanded role of the Agency will be required of the Office of Research and Development. Current ORD programs are consistent with the legislative mandates of the Act, but the level of effort should be acclerated to meet the mandated action deadlines (see Section II).

Interprogram Aspects

An interprogram approach is required for the subject area because solid and hazardous wastes are produced in all sectors of the economy. Major efforts will be provided by the Waste Management; Minerals, Processing and Manufacturing; and the three energy subprograms, with support from several other subprograms.

Five-Year Plan

The primary consideration for program requirements for the near term is upgrading of existing programs to provide the technical backup or support for the short lead-time, mandated actions to be carried out by the Agency. ORD's budget for Resource Conservation and Recovery has been increased to $7.7 million in FY 78 to intensify efforts in the following subprograms.

Waste Management--

Priority research requirements for support of the short lead-time requirements of the Act include leachate sampling and testing, leachate attenuation, toxicity studies, remedial actions for past environmentally unsound practices, evaluation of liners, and hazardous waste treatment methods.

Priority efforts for nonhazardous wastes include mathematical modeling of leachate and gas flow from landfills, within-fill gas control, field sampling for metals analysis and site selection criteria development.

Later deliveries are scheduled for research on storage, collection and transfer, techniques for estimating leachate generation, use of non-soil materials for landfill cover, land disposal techniques, socio-economic and environmental impacts, pilot scale field evalutions of rapid decomposition and stabilization of landfill under optimum conditions, co-disposal of sludge with municipal solid wastes, and testing of several new technologies for disposal of municipal wastewater treatment sludges, including thermoradiation treatment and advanced dewatering technology.

Minerals, Processing and Manufacturing Industries--
Priority research areas include arsenic fixation and recovery, linings for industrial sludge sites, and health and ecological effects studies related to industrial waste disposal.

Energy Conservation, Utilization and Technology Assessment--
Resources are required to support the development of the full range of regulations and guidelines required and permit the preparation of required reports to Congress. Included are such items as pollution measurement, characterization and control, explosion control in shredders, air classifier comparative testing, storage and handling of prepared fuels, and wastes-as-fuel.

SECTION IV

INTERAGENCY ACTIVITIES

BACKGROUND

Prior to the creation of the Environmental Protection Agency (EPA), much, if not all, of the environmental research and development conducted by the Office of Research and Development (ORD) predecessors was accomplished in recognition of other Federal research activities relevant to the environment.

In many cases ORD administrative policy was established internally to assure that cooperation within the Federal establishment was accomplished. This was prompted largely by the definite desire to minimize the duplication of R&D within the Federal government.

Additionally, ORD researchers, as a matter of staying current in the field of research, maintained an awareness of environmentally relevant R&D throughout the government.

The predominant interaction between Federal agencies during the early years was, however, primarily one of consultative exchanges on environmental matters, although in some areas there were specific cooperative ventures undertaken.

Since a successful research and development program is as dependent upon effective communications as it is upon scientific breakthroughs, both EPA and ORD, born of elements of a multitude of other Federal agencies and departments, have maintained a high level of interagency communication and cooperation in order to achieve their objectives. Futhermore, Executive Reorganization Act Number 3 (1970) which created the EPA specifically requires the Agency and its Administrator to cooperate extensively with other Federal agencies in pursuing efforts of mutual interest and responsibility. Thus, the spirit of interagency exchange pervades EPA's very history as an Agency.

There is no clear-cut division of environmental research from other types of research being conducted by Federal agencies in support of their respective missions. The latest developments in space technology, occupational health research, drug analysis, cancer research, or energy process development, for example, may well be as relevant to environmental research objectives as to the mission objectives of the sponsoring agencies.

For this reason ORD has invariably been active in interagency exchanges. This has been accomplished by formal contacts and participation in task forces and advisory committees with other agencies. As a result ORD researchers have maintained a high level of interaction with their technical peers throughout the Federal establishment.

CURRENT STATUS

The recent energy legislation which has led to an ORD Energy-Environmental Program provides an example of the extent of cooperation and coordination ORD can undertake on environmental issues. In addition to the energy effort there is already instituted in the various ORD programs extensive inter-agency efforts of cooperation. Table 11 is a summary of the nature and extent of cooperation between ORD and other Federal agency activities relevant to the environment. It should be noted that ORD is involved with more than seventeen other Federal departments and independent agencies. Most extensively involved in these activities is the ORD Office of Energy, Minerals, and Industry (OEMI). This office coordinates an Interagency Energy-Environment Research and Development Program and sponsors interagency symposia and issues reports on the "pass-through" research activities.

A large measure of the success of OEMI interagency program stems from the management approach used since its initiation. Here the need for substantive information transfer between researchers and research managers is emphasized while controlling the amount of paperwork necessary. In short, the management approach is to cut the red tape and get on with the work. Each major annual task within this program requires only a single sheet of paper to initiate, and status reports are required on a semi-annual rather than monthly basis. Overall "umbrella" agreements negotiated between EPA and each of the participating agencies, at the inauguration of the program, contain all of the legal considerations and allow for a highly simplified planning and reporting process. Additionally interaction between researchers is stimulated via various review mechanisms. Perhaps the most effective of these are the sector groups--issue-oriented groups of representatives from relevant agencies which meet periodically to exchange program status information. The essence of these meetings is widely distributed to appropriate parties. Such interactions are, of course, in addition to the traditional information transfer mechanisms such as seminars, symposia, research and executive reports.

The effectiveness of ORD's interagency involvement is therefore highlighted by the Interagency Energy-Environment R&D Program. Inaugurated in Fiscal Year 1975, this program combines the efforts of seventeen Federal agencies and departments in implementing approximately one hundred million dollars per year in energy-related environmental research. The entire program is planned and coordinated by OEMI, which contributes, approximately one-third of the program's resources to other agencies for the implementation of mutually agreed upon tasks. The remainder of the tasks are imple-

TABLE 11 ORD INTERAGENCY PROGRAM

Research Programs and Subprograms	Federal Agencies and Departments																
	DOL (OSHA)	DOI (BLM-USGS-BOM-FWS)	DOT (USCG)	DOC (NBS-NOAA)	ERDA	FEA	USDA (ARS-FS)	NRC	TVA	NASA	DO-ARMY	HUD	NSF	DO-NAVY	HEW (NIEHS-NIOSH-NCI-FDA)	DOS	GSA
Health Ecological Effects	○	●		○	●				○		○		●	○	●	○	○
Health Effects	○				●										●		
Ecological Processes and Effects		●		●	○		●				○			○			
Transport and Fate		○		○							○		○				
Public Services Activities																●	
Waste Management		○	●				○		○		●					○	
Water Supply															○		
Environmental Management			○			○						○	○				
Industrial Processes																●	
Renewable Resources		○					●										
Minerals, Processing and Manufacturing		○	○		●		●				○			○			
Energy		●			●	●	●		●							●	
Extraction and Processing Technology		●			●	●											
Conservation Utilization,Technology Assessments					●	●			●				○				
Health and Ecological Effects		○		●	●	○	○		●	○			○		●		
Monitoring and Technical Support																●	
Monitoring, Techniques & Equipment Development		○		○	○					○				○	○		
Quality Assurance		○	○	○			○	○		○	○			○			
Technical Support		●	●	●	●	●	●		●	●	●	●			●		

● Fully coordinated.
○ Coordinated in some areas or specific projects

mented within ORD laboratories or via contracts and grants. Such tasks range from small-scale experiments with various remote sensing techniques (with NASA), to the monitoring of synthetic fuel plants (with ERDA), to the determination of oil spill impacts on productive marshes (with DOI-FWS), to major multi-million dollar demonstrations of alternative flue-gas desulfurization technologies. Via the OEMI program approach, several advantages are obtained. First, researchers and research managers who share the common goal of developing domestic energy resources in an environmentally acceptable manner also share a common management system and communications structure. Second, this common structure stimulates direct communications across agency lines to help assure that environmental concerns guide major energy development decisions. Third, the involvement of these agencies resources allows the most effective use of experience and expertise wherever they exist within the Federal sturcture--those researchers most familiar with a resarch area are chosen to implement and monitor tasks related to that research area, regardless of their agency affiliation. This is accomplished by using OEMI funds to supplement existing research efforts in these agencies. Four, the higher-than-normal level of interaction between the agencies helps to avoid duplication of research while, at the same time, highlighting those areas which need further investigation. Five, the EPA role as planner and coordinator of this interagency program provides a central source of responsibility and information for the scientific community, Congress and the people.

The OEMI interagency program, and other major energy-related environmental research and development programs within the Federal government, (e. g., ERDA) and outside of the government (e.g., the Electric Power Research Institute) approach their energy-related environmental analyses and technologies from different perspectives. Each of these perspectives is, perforce, somewhat limited, but essential to achieve a comprehensive, well-balanced energy development decision-making process.

TREND

Major ORD interagency agreements in FY 76 amounted to over 25 milion dollars as shown in more detail in Table 12. In the health effects research area it is anticipated that during the FY 1977 - 1981 period extensive growth in interaction with other Federal agencies will occur.

Since the passage of NEPA and ensuing environmental legislation interagency cooperation has become more prevalent as the need became more apparent, and as specifically requested in new environmental legislation. This tend toward cooperative exchanges has not as yet resulted in placing the EPA in the distinctive role of coordinating or in providing leadership on environmental R&D efforts. This is partly as a result of constraints, of an institutional nature, of manpower resource limitations, and of uncertain or unclear legislative authority with respect to lead-role relationships, and from the lack of specific working mechanisms to conduct Federal integrated environmental R&D.

Most recent legislation reflects a definite intent of the Congress on the role that EPA should have in coordinating R&D. In view of the trends and due to the nature of the environmental theme it is an objective of the ORD to not only engage in cooperative R&D but to substantially achieve a highly effective coordinating status within the current five year plan.

TABLE 12

MAJOR* ORD INTERAGENCY AGREEMENTS FY 76

Agency	IAG Title	Funding ($K)
Commerce - NOAA	Research & Operational Meteorological Suppt, Service	1,960
ERDA - Nevada OPNS Office	Offsite Radiation Protection & Surveillance Program	3,800
NSF	Pest Management Research and Development Program	820
HEW - FDA	Continued Support of Toxicological Research	5,000
ERDA	Biological Screening & Testing	663
ERDA	Development of Cytological and Biochemical Indicators	1,065
ERDA	Population Exposure to Hazards Associated with Non-Nuclear Energy Production	556
ERDA	Trace Contamination From Coal Combustion	765
Commerce - NBS	Water Quality Assurance and Instrumentation	500
Interior - Bureau of Mines	Coal Washing Test Facility	550
Interior	Major Coastal Ecosystem Characterization and Methodology Related to Oil and Gas	950

*Greater than $500,000

Interior	Ecological Methods for Assessing Impacts to Wildlife in Coal Areas	700
Commerce - NOAA	Environmental Assessment of Northern Puget Sound and Strait of Juan De Fuca	920
TVA	Development of Flue Gas Desulfurization Technology--Shawnee Lime/Limestone Scrubbing Program	3,250
USDA - Forest Service	Impacts of Mining and Airborne Pollutants on Forest Ecosystems	583
USDA - Forest Service	Controlling Adverse Effects of Mining on Forest Ecosystems	539
HEW - Nat. Ins. of Env. Health Scncs	Toxic Agents Associated with Non-Nuclear Energy Technologies	753
HEW - Nat. Ins. of Env. Health Scncs	Effect Relationships for Physiological Effects of Toxic Agents	525
HEW - Nat. Ins. for Occ Hlth & Saf.	Health Hazards in Extraction and Processing of Energy	1,889
	Total	25,785